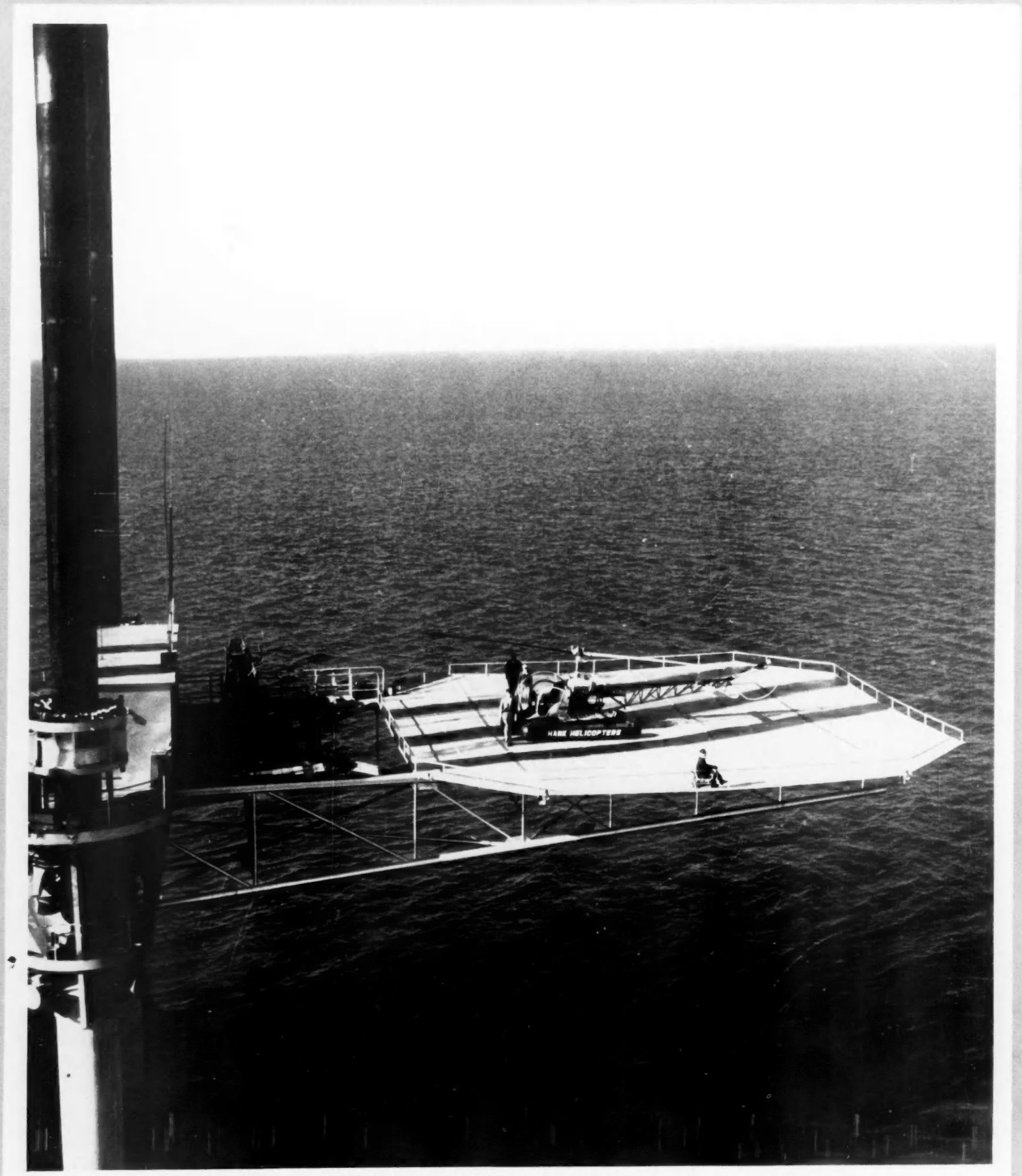
ENGINEERING 30-8-57

ENGINEERING

An Illustrated Weekly Journal

35 & 36 BEDFORD STREET, STRAND, LONDON, W.C.2 - - TELEPHONE: TEMPLE BAR 3663

Vol. 184 No. 4773 *LONDON, FRIDAY, AUGUST* 30, 1957 PRICE 2s.



HELICOPTER PLATFORM ON AN OFF-SHORE DRILLING RIG

AUGUST 30, 1957 VOL. 184 PAGES 257-288

ENGINEERING

An Illustrated Weekly Journal

Vol. 184 No. 4773 AUGUST 30, 1957

Leading Article
Things to See, Things to Think About 257

Plain Words 258

Special Articles
Things to See at the Farnborough Show, and Government Sponsored Research 259 260

Letters to the Editor
Foundations which Vibrate 261
Splendid Heritage 261

Companies in the News 262

Exhibitions and Conferences 274

Book Reviews
Isambard Kingdom Brunel: A Biography 278
Feeding the Press 278

New Books and Trade Publications 279

On the Shelf 279

Atomic Review
More Progress Report 283

Notices of Meetings 285

Automobile Engineering
Automobiles and Environment 286
Activity in the German Motor Industry 286

Plant and Equipment
Prologue to the Exhibition: Enter Atomic Energy 263
The Engineering Exhibition at Olympia 264

Management
Weekly Survey 272

Marketing 273

Design
Limited Life Design: A Survey of the Problem 275

Research and Development
Reinforced Holes in Plates: Total Weight Reduced by Varying Thickness of Reinforcement 280

Metals and Materials
Steel Facts and the Future 281
Opportunities for Nickel 281
Geophysical Surveys from the Air 281
Higher Prices for Raw Materials 281
High-Purity Silicon 281

Production
Adhesives, Emulsions and Compounds: New Factory for Products with Many Engineering Uses 282
Eland Convairs for Brazil 283

Construction
Britain's Part in Irrigation and Drainage 287
Scaffolding Technique for Cooling Towers 287

The Human Element 288

★ ★ ★

Published every Friday by Engineering Limited, 35 & 36 Bedford Street, Strand, London, W.C.2
TELEGRAPHIC ADDRESS *Engineering, Lesquare, London* TELEPHONE *Temple Bar* 3663

Subscription Rates for 12 *months, Inland and Abroad* £5 10*s.*, *Canada* £5 5*s. Subscriptions for periods of less than* 12 *months are based on the price of a single copy including postage* (2*s.* 3*d.*)

THINGS TO SEE

THIS is the season of exhibition and conference fruitfulness—a host of things to see and things to think about. Once the holidays are over, the organisers of stands and papers are ready with their visual enticements and their intellectual challenges. Many months of planning are crowned by a few weeks of exhausting duty at the exhibition stand or a few days of hectic, jostling meetings. Down the aisles between the stands come the rubber-necked gazers, the diligent seekers of free samples, the collectors of catalogues, any of whom may one day join that select company—the serious buyers

The exhibition highlights of the next few weeks are the Engineering Exhibition at Olympia (London's largest indoor exhibition site), the Society of British Aircraft Constructors' flying display and static exhibition at Farnborough, the Radio Show at Earls Court, the Machine Tool Exhibition at Hanover, and the three motor shows—at Frankfurt, Paris and London. The Engineering Exhibition, which opened this week, has been going since 1906. Its strongest tradition and most continuous theme is the marine aspect of many of the exhibits. Before the First World War the pride of engineering were the triple-expansion and quadruple-expansion steam marine engines —have there ever been, before or since, such aristocratic engines? To-day their place is taken by the oil engine—more compact but still impressive. For the first time at the exhibition, nuclear energy is specially featured, along with welding equipment. The combination of marine, welding and atomic energy is a happy choice because the extension of difficult welding techniques has played a major part in the application of nuclear energy and because the new form of power is likely to find its first commercial transport application in ships. The stands at Olympia, however, are not restricted to heavy engineering; instruments, small tools, accessories, etc., certainly outnumber the towering engines.

While the Engineering Exhibition runs its course practically undisturbed by the general public and their media of popular entertainment—television and the daily Press—the Society of British Aircraft Constructors fight a stern battle to restrict the first few days of their show to *bona fide* visitors. Here is an exhibition which has everything—the finest visual display, the most advanced scientific and engineering achievements, and an atmosphere which combines the earnestness of a learned society and the jollity of a trade show. If the writings of H. G. Wells were not already surpassed by reality, it might be described as a Wellsian garden party. Small wonder the S.B.A.C. resist suggestions that it should be held every other year instead of annually.

The Olympia and Farnborough shows are being covered in this and subsequent issues of ENGINEERING. Technical trends revealed in the Radio Show will be reported in next week's issue and automobile design will be reviewed in a series of articles at the time of the London Motor Show.

THINGS TO THINK ABOUT

Into the conference rooms come the authors of papers, the discussion contributors and the seekers of knowledge. The British Association meeting is the " popular " event of the year. It is the Festival of Science, the one scientific meeting where the specialist humbles himself to learn about the advances of other specialists, and where the daily Press, on behalf of its mass audiences, picks up the tit-bits of all the sciences, fundamental and applied.

The B.A. meeting opens at Dublin next week, with the president, Professor P. M. S. Blackett, F.R.S., addressing his audience on a subject of common interest to scientists, engineers and politicians—" Technology and World Advancement." The Engineering Section of the Association always attracts a group of valuable papers. The tradition of publishing these papers in ENGINEERING is continued this year, and they will appear in the journal during the next few weeks.

The other conference highlights of the season are the International Conference on Operational Research which is to be held at Oxford next week, the Anglo-American Aeronautical Conference at Folkestone, and the Conference on Lubrication and Wear organised by the Institution of Mechanical Engineers. Operational research is a relatively new tool of management—a scientific means of reaching decisions of policy which is likely to revolutionise business management just as fast as the people who can apply it and those who can use it are able to speak a common language.

The harvest season—and the planting season. A time when there is a new surge of activity in industry, new ideas fill the air, new contacts are made. An enterprising exhibition organiser may some day provide visitors with those little self-propelled vehicles that American golfers use to eliminate walking from the game. But nobody is likely to provide a substitute for the human brain; on the contrary, all the electronic computers and the unknown inventions of the future will tax the human brain to its limits. There will be more than ever to think about.

Cover Picture. *The picture shows the view from an aircraft approaching a new off-shore drilling rig recently erected in the Gulf of Mexico to extend the search for oil. The built-in helicopter port is on the same level as the service platform which houses the supplies store and the drilling crew's quarters.*

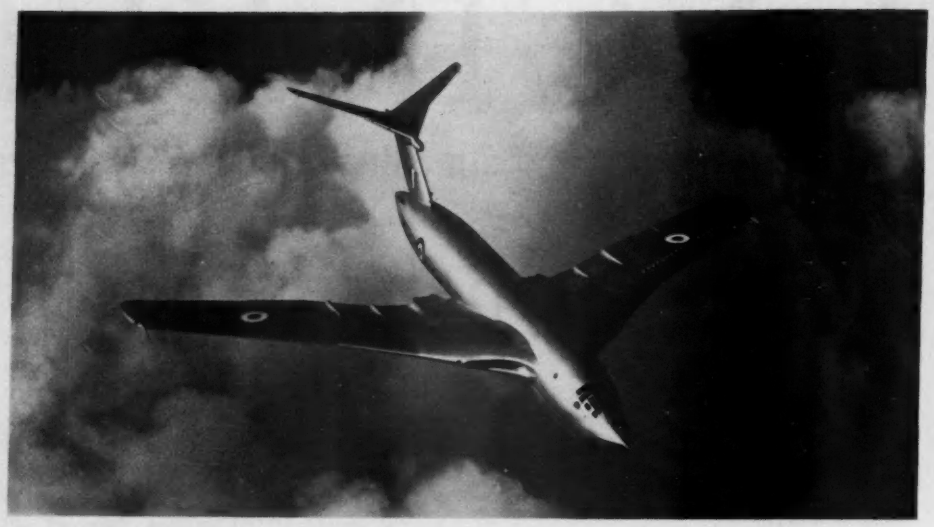
* * *

Plain Words

A continuous stream of information pours into the offices of newspapers and technical journals. Most of it to-day is sent out by Press and publicity officers acting as employees of the organisations desiring publicity or as agents who specialise in this kind of work. Their function offers as much scope—at one extreme for efficient service and at the other for time-wasting inanity—as journalism itself. When, therefore, a new book on the subject was published recently, rather than review it ourselves we decided to invite one who has wide and varied experience in this field to assess it and at the same time to let off some steam if he wished. His review appears on page 278 under the heading "Feeding the Press."

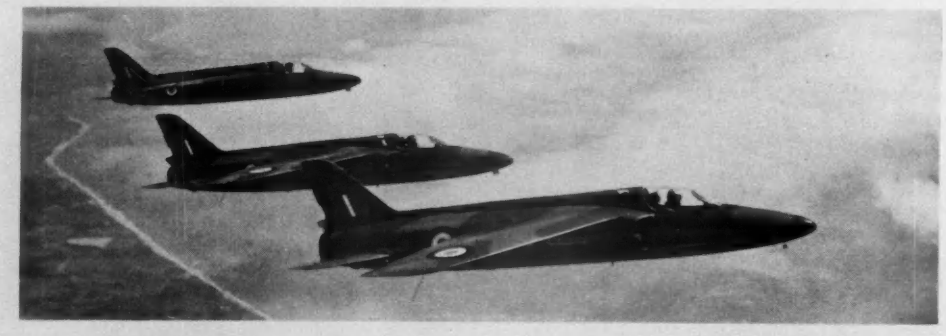
His criticisms, even if they are not accepted unreservedly, must certainly be respected. He writes with first-hand knowledge and experience of publicity work. He knows something of American as well as British practice. His chief criticisms are that many industrialists in this country "view their Press officers as necessary evils," and that dealing with the overseas Press is an aspect of public relations which has been almost entirely ignored by industry. If these charges are justified—and they are probably as true and as false as most generalisations—it is because not so many years go British industry and its products required no deliberate policy of public relations to put them over. The belief persists that if the business enjoys a high reputation and the product is sound, sales will follow as surely as the night follows the day. Even among a minority of customers, the belief persists that the products of a reticent firm are in some way preferable to those of a publicity-minded firm. There is, as it happens, some truth in that belief: mass sales only go to the widely advertised and publicised product; mass sales usually involve mass production; and mass production usually implies a quality somewhat less than the top.

To argue thus, however, is to miss the point. The fact is that, to-day, enterprise in design and production is invariably accompanied by enterprise in all aspects of marketing, including public relations. In a company which is directed with foresight and ability all the departments set a swift pace—research and development, design, production or construction, sales and marketing—and their combined momentum exerts pressure and a common desire to tell the world. They are good, they know they are good, and they want everyone to know they are good. That is the spirit which makes businesses hum. And that is the spirit which gives power to the Press officer.

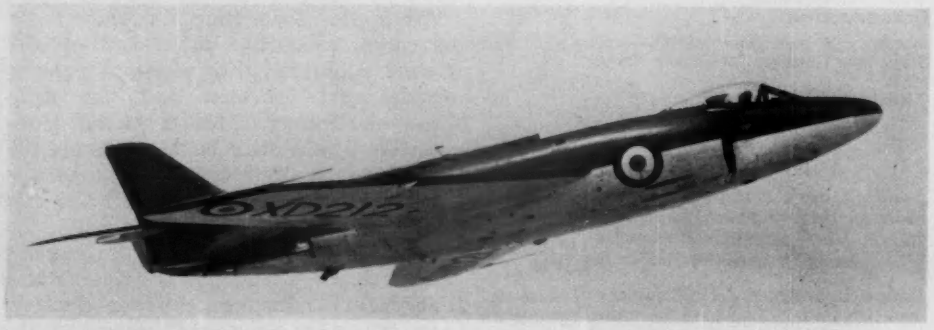


The Handley Page Victor bomber is now entering service with the Royal Air Force.

The Hunter Mark 6 interceptor, which is superseding the Mark 4 in squadron service with the Royal Air Force, appears this year with a modified "saw-tooth" leading edge.



Six Folland Gnat fighters, four of which have flown, are on order by the Ministry of Supply; India has ordered 25 and Finland 12, and both countries have taken building licences.



The Vickers-Armstrongs Scimitar naval all-weather fighter has successfully completed deck trials.

THINGS TO SEE AT THE FARNBOROUGH SHOW

Starting on Monday next, the annual flying display and exhibition of the Society of British Aircraft Constructors will be held at Farnborough—once again the "biggest ever," with 350 exhibitors this year. The public will be admitted on Friday, Saturday and Sunday, September 6-8; Monday is reserved for technicians of the aircraft industry and Tuesday, Wednesday and Thursday for overseas buyers and other invited guests.

The main technical interest is the display of guided weapons and associated components and equipment, on view to the public for the first time. The guided weapon systems include Fairey Fireflash and de Havilland Firestreak air-to-air weapons; the Armstrong-Whitworth Sea Slug naval ground-to-air weapon; and the Bristol/Ferranti Bloodhound and English Electric Thunderbird ground-to-air weapons. There are, in addition, several new prototype aeroplanes appearing in the flying display: a new propeller-turbine feeder-airliner, the Aviation Traders' Accountant; the H.D.M.105 high-aspect-ratio light-transport aircraft; the Miles Student jet trainer aircraft; the Saunders-Roe SR53 mixed-power supersonic interceptor. Three other 1,000 m.p.h.-plus aircraft are taking part: the record-holding Fairey F.D.2, the P.1A experimental aircraft (Sapphire-powered, and with a modified wing), and the Avon-powered P.1B (the operational version). This latter aircraft appears in public for the first time.

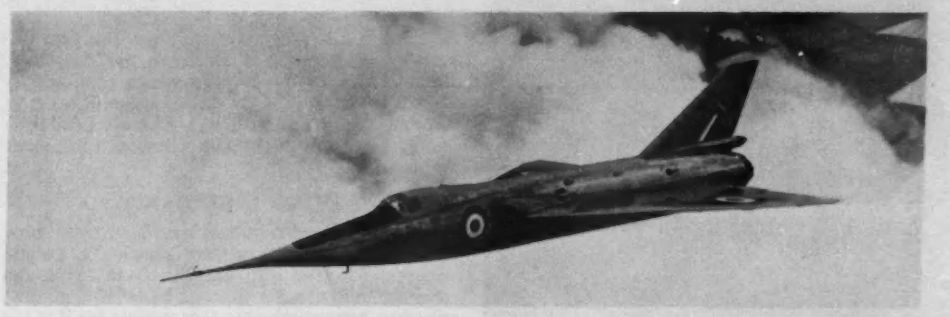
The first group in the flying programme comprises a Fairey Gannet trainer, an English Electric Canberra bomber, a Hawker Hunter aircraft with reverse thrust, three new flying test-beds—a Spectre-Canberra, a Gyron-Junior-Canberra, and a Conway-Vulcan—a Britannia fitted with an Orion, a Proteus 755 and two 705 engines (on September 3, 4 and 5 only), an Olympus-Canberra of the type which holds the altitude record for aeroplanes, and the Scorpion-Canberra test-bed which returned recently from Tripoli.

Helicopters will include the new turbine-powered Westland Wessex, fitted with a Napier Gazelle; two Whirlwinds, a Widgeon, the Bristol 173 twin-rotor machine, two Fairey Ultra-Light helicopters, and a Saunders-Roe Skeeter with Napier rotor-tip rocket boosters.

Transport machines, carrying selected guests, include the de Havilland Comet 3, the Scottish Aviation Twin Pioneer, the Handley Page Herald, and the Hunting-Percival Pembroke. On September 2 and 3 only, the Accountant will fly past. The H.D.M.105 and the Student will follow with individual demonstrations.

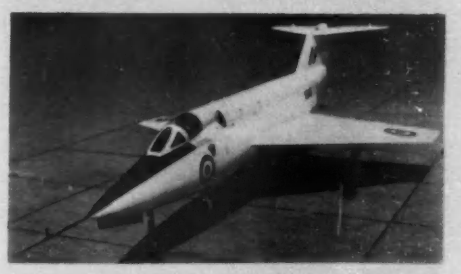
Then follow the Hunting-Percival Jet Provost trainer, now the standard trainer for the Royal Air Force; the Folland Gnat lightweight fighter, on order for the air forces of India and Finland; a Gloster Javelin all-weather fighter, a group of four Hunters (one T Mark 7 two-seater and three Mark 6 aircraft, which now have a modified wing leading edge); the Royal Navy's latest deck-based fighter, the Vickers-Armstrongs Scimitar, with blown flaps, and the de Havilland Sea Vixen; two V-bombers of the the type which will carry the "stand-off" bomb, the Handley Page Victor, now entering service, and the Avro Vulcan Mark 2 prototype (shown for the first time).

In addition, for the first time in the history of the S.B.A.C. show, there will be a demonstration by the Royal Navy—a formation flight of Gannet anti-submarine aircraft, a display of high-speed aerobatics by five Sea Hawk interceptors, and a "calypso" by Whirlwind helicopters. The Royal Air Force, too, will contribute a fly-past by 27 Hunters and 27 Javelins, high-level flights of more than 50 Valiant and Canberra bombers, a low-level flight in loose formation by a Victor, a Vulcan and a Valiant, and aerobatics by Hunter fighters and Provost trainers.

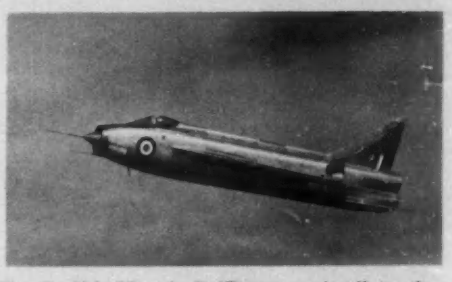


The Fairey F.D.2 supersonic research aircraft still holds the world air-speed record (1,132 m.p.h.) under controlled conditions.

The Bristol-Ferranti Bloodhound, now in production, will replace Britain's home-based defence fighter aircraft.

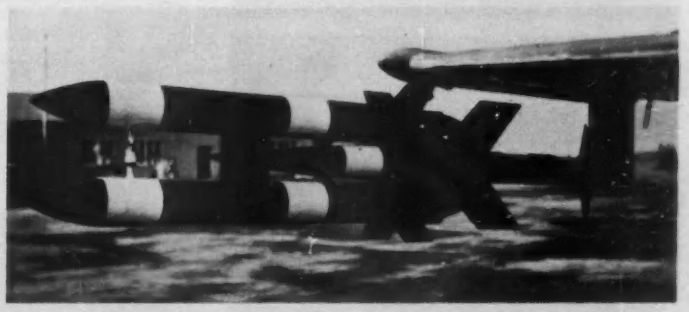


The Saunders-Roe SR53 supersonic mixed-power interceptor prototype is powered by a Viper turbo-jet and a Spectre rocket.

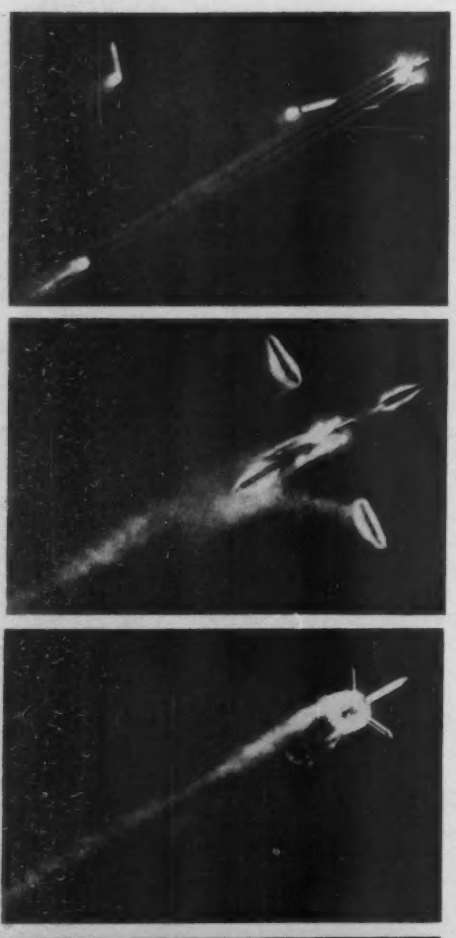


The English Electric P.1B supersonic all-weather fighter aircraft under development for the Royal Air Force.

The Fairey Fireflash, Britain's first air-to-air beam-rider guided weapon, seen here mounted on a Hunter Aircraft. Fireflash is now in service on Swift 7's as a training weapon.



The de Havilland Firestreak is an infra-red homing air-to-air weapon.



Sequence of test-firing a general-purpose test vehicle. The last pictures show the boosts breaking away.

GOVERNMENT SPONSORED RESEARCH

FARNBOROUGH EXHIBITS OF THE MINISTRY OF SUPPLY

At the S.B.A.C. Farnborough Show this year the missiles programme is, perhaps, the dominant theme. One of the exhibits which promises to attract the crowds is the guided-weapon homing demonstration by the Royal Aircraft Establishment, to be seen in the covered equipment section.

HOMING GUIDANCE

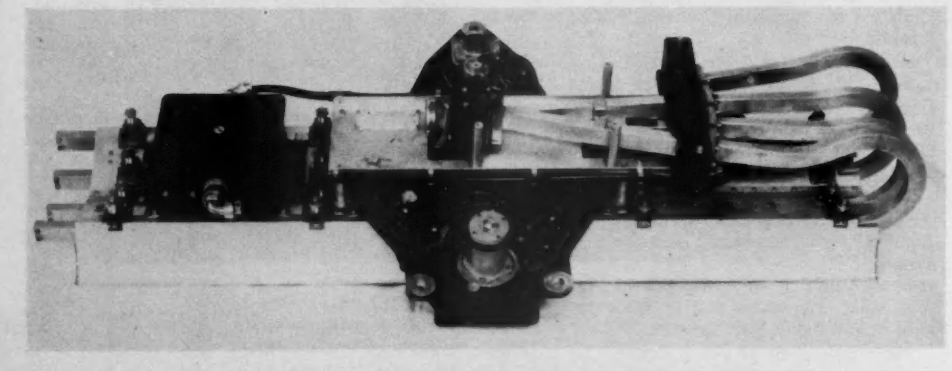
In the demonstration, which is to show how a homing guidance system enables a guided weapon to close with an aircraft in flight, the scanner in the radar homing head of a guided-weapon general-purpose test vehicle (G.P.V.) is locked on a moving dummy target, and follows the target's evasive action. Information on the target motion, signalled from the homing head to the control system, causes the latter to operate the vehicle fins so as to counteract the target's manoeuvres.

The 25 ft. long G.P.V. used in the demonstration is one of a current series of flight rounds, and will be fired shortly at Aberporth. The missile, its propulsion system, and telemetry, have been developed by Short Brothers and Harland Limited, Belfast; the current G.P.V., which is fitted with cruciform wings and control vanes, is propelled by eight solid-fuel boost rockets which fall away after burnout, and a liquid-fuel sustainer-motor operating on hydrogen peroxide and kerosine, the propellant tank capacities being 5·69 cub. ft. (H.T.P.) and 1·04 cub. ft. (kerosine). During the trials two different methods have been used for supplying fuel to two types of motor, and both combinations have proved 100 per cent. successful. The vehicle has been designed to allow the installation of a solid-fuel sustainer in place of the liquid-fuel rocket. The guidance and control equipment is supplied by Elliott Brothers (London) Limited, Boreham Wood, Hertfordshire.

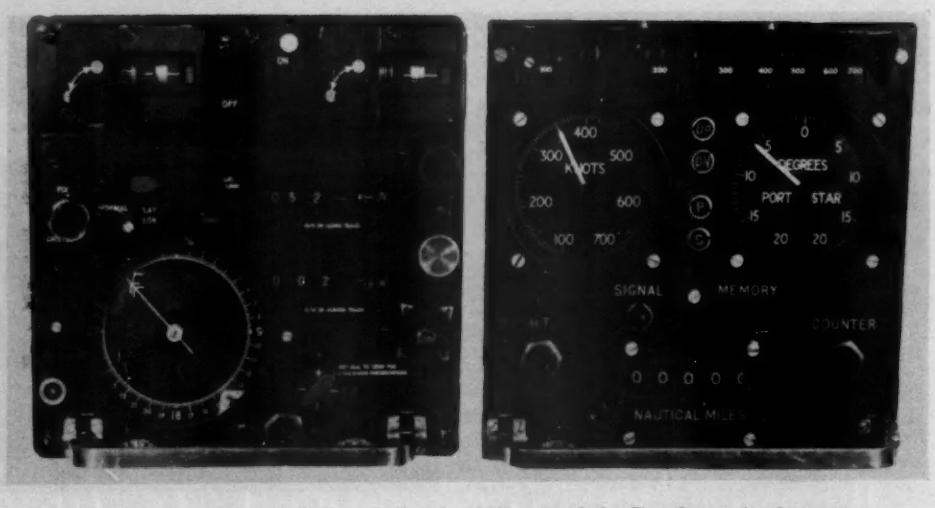
The two firms are working in close collaboration with the Royal Radar Establishment and the Royal Aircraft Establishment on a research programme into problems of homing guidance, the results of which are being made available to all firms in Great Britain working on homing missiles. The subject involves an intensive study of all the difficulties to be overcome in achieving accurate interception of a high-speed target flying at great altitude. This study is being carried out at Elliott Brothers, using electronic analogue and digital computers. In order to verify the results obtained, flight trials are carried out using G.P.V. fitted with guidance and control equipment; rounds are prepared and fired by a joint Short Brothers and Harland/Elliott Brothers team at the Ministry of Supply range at Aberporth. A test firing sequence of a G.P.V., from launching to the break-away of the boost motors, is shown in the accompanying illustration.

SERVOS

Servo systems designed by the Royal Aircraft Establishment are also to be demonstrated by the guided weapon department. To demonstrate the power amplification and response of a typical guided-weapon electro-hydraulic servo, the actuator installation for the G.P.V. in the homing demonstration, carried out by H. M. Hobson Limited, Wolverhampton, in conjunction with Short Brothers and Harland, is on view. The demonstration servo is controlled from a standard guided-weapon gyro potentiometer attached to a suitable lever; visitors will be able to test the sensitivity, speed of response and smoothness of servo movement by operating



Aerial system of the Doppler navigation equipment.



Ground position indicator (left) and direction indicator of the Doppler navigation system.

the lever. This basic design has been used for several other applications, including wing servos for control test vehicles, simulator servos, and experimental flying-control servos. The principal data are: stall torque, 1,750 lb.-in. at 2,000 lb. per sq. in.; load inertia, 60 lb.-in.^{2}; design operating pressure, 2,000-3,000 lb. per sq. in.; maximum deflection, $\pm$ 32 deg.; maximum speed of response, 750-900 deg. per second; hydraulic h.p., 3.

Also on view will be a more powerful moving-wing servo ring, designed and made at the R.A.E., containing four 10 h.p. electro-hydraulic servos operating at pressures up to 4,500 lb. per sq. in. Each servo operates a wing surface, and they can be operated independently. The wing surfaces can be readily changed. The oil-supply system can either be of the total-loss system for short flights, as shown at Farnborough, or a circulating-pump system for long-duration flights. The high working pressures and high power output from the single-stage servos are particularly impressive. The principal particulars are: stall torque, 3,500 lb.-in.; load inertia, 200 lb.-in.^{2}; design operating pressure, 3,800-4,500 lb. per sq. in.; maximum speed of response, 1,200 deg. per second.

DATA TRANSMISSION

Within the static exhibition hall, on the M.O.S. stand, there can be seen a data transmission system receiving information from guided-weapons trials at Aberporth, Wales, for calculation on the Deuce computer at Farnborough. This system has been devised by the Trials Department of R.A.E. to speed the transmission of information on punched cards over long distances, and to guarantee its correctness. Information stored on punched cards is converted to a teleprinter signal and transmitted to a receiving station, where duplicate cards are produced. The transmitter adds the numbers on the cards as they are sent and the receiver adds them as they are received. If the sums agree, a signal from receiver is sent to the card reader at the transmitting station and a new card is fed. If the sums do not agree, the card reader is made to re-feed the same card.

INSTRUMENTS AND NAVIGATION

Turning back from guided weapons to the conventional aircraft, there have within the last two or three years been great advances in equipment for helping the pilot to fly and navigate his aeroplane. Examples on view on the M.O.S. stand include an integrated flight-instrument system, designed for the increased performance and space limitations of the present-day fighter aircraft, which presents all the information, derived from centralised data sources, the pilot needs to fly the aircraft—including I.L.S. data (instrument landing system) and TACAN range and bearing—on four easily read indicators; and the self-contained Marconi Doppler navigation equipment, which was developed in conjunction with the Royal Radar Establishment, which automatically gives the aircraft its position without reference to ground stations (described in the July 19 issue of ENGINEERING). Components of the Doppler navigation system are shown in the illustration opposite.

HOT TURBINES AND COOL RADIO

Other exhibits on the M.O.S. stand are concerned with researches, one directed to running gas turbines at higher temperatures, and the other to ensuring that radio components are adequately cooled. Examples of air-cooled turbine blading that has run at gas temperatures of 1,400 deg. K. in the experimental high-temperature gas turbine at the National Gas Turbine Establishment (ENGINEERING, October 14, 1955) will be on view. Three techniques have so far shown great promise—the extrusion process developed by Henry Wiggin and Company, Limited, sintering, and investment casting with silica mould inserts. Brazing techniques are not yet sufficiently reliable for application to engine production.

A new technique for measuring the optimum cooling flow required by radio equipment in high-speed aircraft without exceeding the safe temperature of the equipment on test, is to be demonstrated by R.A.E. Radio Department. Components which temperature-indicating lacquers have shown to be approaching their limit temperatures are instrumented by thermocouples connected to an automatic recorder, enabling the critical component to be selected and the optimum cooling flow extrapolated from time-temperature curves.

Letters to the Editor

FOUNDATIONS WHICH VIBRATE

SIR, The problem of designing a concrete foundation block or raft for a reciprocating engine or compressor is rendered difficult by uncertainty regarding the elastic properties of the subsoil. In order to reduce the vibration of the foundations as much as possible, it is usual to try to arrange that the natural frequency of the block on the resilient soil is not less than twice that of the fundamental of the pulsating force, and above all to avoid resonance, either with the fundamental or any important harmonic. If, due to the use of incorrect data on the soil or for any other reason, resonance is encountered it is usually an expensive matter to modify the foundation block so as to change the natural frequency sufficiently to avoid the resonance. Various ways of effecting such a change have been proposed, e.g., by adding mass to the block or by altering the water content of the soil. The latter alters what is loosely called " the natural frequency of the soil " but is really the natural frequency of the mass-soil system corresponding to a certain load per unit area on the soil.

An alternative method is put forward by S. H. Fistedis in a paper, " Vibration-Resistant Prestressed Concrete Foundations for Engines and Compressors," to the recent World Conference on Prestressed Concrete. He suggests including wires in curved holes in the concrete bed so that, if resonance is encountered, the wires can be post-stressed so as to redistribute the soil loading under the bed and alter the natural frequency. However, it is clear on reflection that the static stresses in the concrete bed and wires constitute a closed system and cannot affect the dynamic stiffness of the soil underneath, except possibly temporarily if the bed bends under this static stress.

No confirmation of the suggested method in practice is given and none would be expected. The incidental effect which is mentioned of stiffening the concrete bed by the post-stressing's closing up any cracks may be helpful.

Yours faithfully,

A. J. KING.

Manchester.
August 23, 1957.

* * *

SPLENDID HERITAGE

SIR, You are so right to praise the B.B.C. for taking television viewers into the stately homes of Britain (your " Plain Words," August 16). It serves to remind me of what is recorded in my book, *The Time for Decision*, from which I quote what might be of interest to your readers.

". . . the wealth and superabundance of those monuments of splendour were erected prior to the Industrial Revolution of the Nineteenth Century, since when very little has been done to contribute to the extraordinary wealth in houses and monuments of the earlier days—because the immense monetary gains of the Revolution were mainly invested abroad, and now, unfortunately, irretrievably lost owing to our impoverishment due to two world wars. But these historical houses remain to demonstrate the English ideal of how best to live, and in them, past and present are marked. . . .

" Let us then applaud these edifices of craftsmanship, which give to Great Britain yet another enrichment of moral leadership. It is comforting to get in perspective the period of time in which the stately homes of England originated, in quoting these in chronological order to envisage the striking changes which took place from decade to decade; then to pull the mind up sharply to the realisation that these wonders of architectural perception in the minds of men have abruptly ceased. In their place the pattern of design has lost the edifying spectacle of magnificence, to give rise to drab and unspectacular buildings, which shall have one thing in common—to provide a shelter for the people to live in—hardly befitting the title of home in the comparative sense of the past. Yet, on reflection, a development restrained by the ever increasing population and the tragic passing of the family life and gatherings, which was so familiarly and intimately English until comparatively recent times.

COUNTRY HOUSES

Castles and abbeys	1066—1500
Manor houses	1300—1500
Tudor homes	1500—1600
Elizabethan Renaissance	1550—1600
Jacobean mansions	1600—1650
Late Stuart	1650—1700
The Golden Age	1700—1760
The Age of Elegance	1760—1800 "

Yours very truly,

FRANCIS B. WILLMOTT.

Birmingham.
August 26, 1957.

WHAT IS THE *QUALITY* OF RUSSIAN ENGINEERS?

Much has been heard in the past few years of the formidable Russian drive to train more engineers. Whether the results are measured in terms of the absolute number of engineers or in the number per thousand of the population, they are greater than the corresponding figures for the United States and much greater than the figures for Western Europe and the United Kingdom. So much for the *quantity*—what of the *quality?*

Mr. E. P. Ward, M.A., A.M.I.Mech.E., a deputy editor of ENGINEERING, flew to Moscow last week to seek the answer to this highly significant question—What is the quality of Russian engineers? Special arrangements have been made with the Russian authorities for him to visit typical engineering establishments. As he speaks Russian he will be better able than most visitors from the West to gather information and present a realistic assessment.

His findings will be published as a series of articles in ENGINEERING, commencing in the issue of September 13.

Companies in the News

Flourishing Plastics

Plastics materials are the subject of interesting comments by the chairmen of two companies whose annual general meetings were held recently, the Distillers Company and Thomas de la Rue and Company. The plastics industry, particularly moulders, were hard hit by the recession in the motor industry and other repercussions of the credit squeeze. The situation has now altered radically and the industry has resumed its expansion of output. The continuous stream of discoveries, improvements to existing plastics materials, new methods of processing, new applications, etc., suggest that it will go on expanding for many years before it is threatened by other materials. Distillers' plastics division benefited during the second half of their financial year (ending March 31) from a recovery in demand which, according to Sir Henry J. Ross, the company's chairman, " showed encouraging growth which still continues although there is keen competition in certain materials." P.V.C., polystyrene and synthetic resins of the epoxy type are the company's most successful products. The arrangement with B. F. Goodrich Chemical Company, U.S.A., to manufacture under licence oil-resistant synthetic rubbers and latex for which British Geon are building a new factory at Barry, South Wales, represents a most important addition to the D.C.L. range.

Mr. B. C. Westall, chairman of de la Rue, tells the full success story of the company's production of laminated plastics at highly competitive prices. The acquisition of the trade techniques and manufacturing rights for Formica laminate from the Formica Company of Cincinnati (now part of the American Cyanamide Company) has proved greatly beneficial. A new agreement between de la Rue and American Cyanamide, whereby the latter will acquire up to 40 per cent. of the equity of Formica Limited, should ensure very close technical liaison with the American company and was described by Mr. Westall as one which will be " of very material value in the years to come." The new Formica company will have a capital of £3 million, an indication of the scale on which this type of laminate has found applications.

* * *

Problems of Change

In electrical engineering there has been a continuous and fairly fundamental change in product design which has posed for some companies exceedingly difficult problems, not least of which has been modifying their production capacity to suit the needs of the atomic-energy programme. None has escaped; even giants such as A.E.I., G.E.C. and English Electric have had their share. Perhaps some of the most radical of all changes have taken place in the field of current rectification, where a new form of high-purity silicon (see page 281) is threatening to displace not only the bi-metal rectifiers (mainly selenium) for a wide range of applications, but also the high-voltage applications currently filled by mercury-arc rectifiers. In switchgear there has been a tendency away from oil-immersed to air-break and from hand-operated to automatic.

These changes have yet to have their full impact on the electrical industry. A number of firms have in fact kept their range of products in line with the change, but others have not or have deliberately delayed doing so until demand for their established products began to decline. In the same industries, however, new firms have sprung up, specialising in the newer versions only. These have generally expanded very fast (some to a large size) but the demand has been such that the older firms have not noticed anything but an increase in their own sales. It will be only when demand falls that the full extent of the relative losses of ground will be revealed with brutal suddenness.

One of the older companies, Hackbridge and Hewittic Electric Company, held their 51st annual general meeting recently for the year ending March 30. Trading profits are down, by £120,000 to nearly £342,000, due to lower margins. Orders booked were nearly a third higher than 12 months previously and in general commercial prospects appeared good. Development work had been carried out on semi-conductor rectifiers, including germanium and silicon, which Mr. Anthony M. Browne, their chairman and managing director, described as " an investment for the future."

* * *

English Electric and Locomotive Exports

The manufacturers of electric locomotives now have a considerable volume of work in hand. Apart from orders placed by the British Transport Commission in connection with the railway modernisation programme it was announced last week that South African Railways have placed with the English Electric Company of South Africa a contract for 55 electric locomotives (class 5E) valued at £3·3 million. This follows an order for 135 electric locomotives valued at £7·6 million placed last month by South African Railways with Metropolitan Vickers of South Africa. The locomotives are each of 2,000 h.p. and weigh about 80 tons. English Electric also have in hand fifteen 3,600 h.p. electric locomotives weighing 118 tons for the Spanish National Railways where 60 English Electric locomotives are already in operation.

About a year ago it was announced that the total value of traction equipment under construction by the English Electric Group was over £10 million and although there was a lull in export orders during the latter part of 1956 and the early months of 1957, this figure must now have grown considerably. Following its acquisition by English Electric in March, 1955, Vulcan Foundry was faced with a major re-organisation designed to switch production from steam locomotives to Diesel, Diesel-electric and electric types. The completion of this work last year added considerably to the productive capacity of the group and will stand them in good stead in completing the heavy volume of work at present in hand.

With the relaxation of the ban on exports to China there are possibilities of further export orders from that country. It has been reported that China requires 200 or 300 each of electric and Diesel locomotives and while she can herself build small electric locomotives of under 2,000 h.p., the larger types will have to be imported for some time to come.

* * *

Mannesmann A.G.

During the last few years a number of German companies have greatly expanded their interests outside Germany, partly through the establishment of subsidiaries in countries where import restrictions and high tariffs have restricted exports from Germany, and partly with the object of assisting the distribution of German products in overseas countries. In some cases, too, this policy of investment abroad has been dictated by shortage of labour and raw materials in Germany.

The annual report of Mannesmann A.G., published last week, shows a marked growth in the company's foreign interests. The turnover of the group's German companies in 1956 amounted to DM. 3,370 million, showing an increase of 17·8 per cent. over the previous year. The crude-steel output amounted to 1·8 million metric tons out of total production in the German Federal Republic of 15·36 million metric tons. The production of steel tubes at 692,000 metric tons compares with 1·5 million metric tons for the Federal Republic as a whole.

The principal development overseas during 1956 was the acquisition of a considerable holding in the United States Algoma Steel Corporation with whom Mannesmann had already concluded a 20-year agreement on the delivery of tube semis before the erection of a tube plant by the company's Canadian subsidiary. The Mannesmann overseas participations are held through the Mannesmann International Corporation, Limited, established in Toronto in October, 1956, with a capital of 30 million Canadian dols., and Overzee Holding Mj.N.V., Curaçao. The number of overseas companies in which the group is interested is now about twenty-five, and these include mining companies, tube mills, manufacturers of plastics and a number of trading companies in North and South America, Scandinavia and Holland.

The need for heavy capital investment in Germany in the immediate post-war years, coupled with the very low standard of living of the German people, brought home to the latter the need for saving to a much greater extent than has been the case in this country. Now that the major work of rehabilitation of German industry has been completed this attitude is persisting and lies behind the ability of German industry to make extensive foreign investment.

* * *

Instrumentation for Growth

The growth of instrument making during the past 30 years has been so great, and so varied, that the leading companies of to-day have tended to specialise in the production of a small range of fairly standard products. There are, however, the older companies who concern themselves largely with what their customers want. Gradually this type of approach to instrumentation is losing its appeal, perhaps because it is so much more expensive with little to justify the additional cost.

George Kent are a good example of a company who have succeeded by confining themselves to a relatively small range of standard products. At the same time they have fitted themselves to sell, install and service " instrumentation." The contract secured recently for the instrumentation and automatic control of the blast furnaces and melting shops of the new works being erected by the Indian Iron and Steel Corporation is a good example of the trend. During the year ended March 30, George Kent made £648,474 trading profit from a turnover of £5·46 million, both turnover and profits showing an improvement on last year. This was achieved despite a sharp recession experienced in the demand for motor car steering gear manufactured in two of the company's factories and marketed by Cam Gears, Limited. The sharp recovery of demand in recent months, coupled with a continued heavy demand for instrumentation, should make for a record performance this year.

The British Thermostat Company who, like Kent, produce a wide range of measuring instruments and controls, also reported a substantial expansion of their business, though profits at £623,473 are slightly lower than last year. The reasons for their difficulties were given by their chairman, Mr. J. E. Sherlock, as being the effect of the credit squeeze upon the sale of automatic controls to the domestic appliance industry. For this reason, the company have " set up a division and made licensing arrangements with a well-known American company to pursue the business of automation and instrumentation, not only for application to our own manufacture but to extend further our fields of activity."

Plant and Equipment

PROLOGUE TO THE ENGINEERING EXHIBITION

ENTER ATOMIC ENERGY

Nuclear science, in a few years, has radiated its influence into every corner of engineering. What factors give nuclear engineering this universal interest? There are three: power, which is fundamental to all engineering work, may one day come largely from nuclear resources; the construction of nuclear plant requires the co-operation of many different specialists, from instrument makers to structural engineers; and thirdly, radiation—from accelerators, from radioactive isotopes or directly from reactors—is proving useful in almost every branch of industry.

It is thus fitting that "nuclear" should have been added to the title of the Engineering Exhibition. The impact of nuclear science on other fields of engineering is discussed below in terms of these three categories: power, manufacture, and radiation. Power and radiation are the services rendered by nuclear energy; manufacture represents the myriad services it requires.

Power

In 1945 the first atomic bomb was exploded. The fission of the heavy uranium isotope, uranium 235, into lighter elements, yielded vast quantities of energy per unit mass. Later the hydrogen bomb was devised, in which the fusion of hydrogen isotopes to form helium evolved even greater quantities of energy per unit mass.

Control of fission energy was accomplished in under ten years, and in countries such as Britain where coal is expected to become increasingly expensive, nuclear power stations are soon likely to be competitive with coal-fired plant. In underdeveloped areas and isolated regions without interconnected electrical grids or access to fossil fuels, small nuclear power stations, of less than 20 MW output, may find a growing use. Thus nuclear energy may sustain industrial growth in countries short of coal, and create industries in territories, such as Antarctica, hitherto considered unexploitable.

Nuclear energy is a source of heat; indeed the nuclear reactor has been described simply as a furnace. Owing to limitations imposed by the available materials, power reactors built so far have produced only low-temperature heat (the coolant-gas outlet temperature at Calder Hall is appreciably less than 400 deg. C.). Though it presents special problems in power-plant design, such heat may be used satisfactorily for space-heating or chemical processing. At Västerås, in Sweden, for example, nuclear plant known as Adam, due to be commissioned in 1960, is to supply 75 MW of energy for district heating, and other projects are planned for process-heating purposes. The desirability of operating nuclear reactors continuously may also lead to the use of nuclear power stations as sources of process heat at periods of low electrical load.

Propulsion and traction are applications of nuclear energy that are as yet in an almost primitive stage. Marine propulsion offers the most likely prospect, since ships are sufficiently large to accommodate the shielding required to protect the passengers and crew from dangerous nuclear radiation. Two American submarines, one the Nautilus, powered by a pressurised-water cooled reactor, and another, Seawolf, by a reactor cooled by liquid sodium, are both reported to have travelled considerable distances, the Nautilus about 60,000 miles on one charge of uranium. A British submarine, likewise using a pressurised-water reactor, is also planned. Unfortunately, reactor propulsion units of this kind are far too costly to be suitable for use in merchant ships. Apart from the high capital cost of the Nautilus's power plant, its use of enriched fuel introduces high running costs. Only one part in 140 of natural uranium comprises the fissile or active isotope, and to increase this fraction by isotope-separation procedures is very costly. But a small reactor, as is necessary in a vessel like the Nautilus, can only operate if it is fuelled with enriched uranium.

For this reason the two British groups that have announced their interest in nuclear propulsion for merchant ships are considering the construction of large nuclear tankers. Cammell Laird and Babcock and Wilcox have reported that a study for a 65,000 ton deadweight tanker has recently been completed. A vessel of this size could accommodate a comparatively large reactor, together with the considerable weight of shielding required; and a gas-cooled graphite-moderated reactor similar to those at Calder Hall, which burn natural uranium, has been proposed. Similar plans have been announced by Hawker-Siddeley—John Brown Nuclear Construction, Limited. The advantages of nuclear propulsion for merchant ships include quick turn-round, since lengthy refuelling would be unnecessary, and the elimination of ballast problems, since the change in weight of fuel during a voyage would be negligible.

Discussions have been held in Germany and America as to the feasibility of nuclear traction for railways. In the remote areas of North America and the Soviet Union nuclear locomotives might conceivably be operated, but even in moderately populated areas the immense hazard involved in the accidental release of fission products entirely prohibits such a development. Military aircraft, where range is an important consideration, offer some prospect for the application of nuclear propulsion, and experiments are proceeding in America with this in view. It has also been reported that the disused Saunders-Roe Princess flying boats may be employed for similar studies in this country.

At the beginning of this section reference was made to the hydrogen bomb and the immense energy liberated from hydrogen and its isotopes when they are fused together to form helium. So far, no means have been discovered of controlling the fusion process, but there is reason to believe that the solution may not be far distant. In that event, almost limitless energy may be available, since hydrogen and heavy hydrogen (deuterium) are available in great quantities in the sea. It is also significant that the fusion process is likely to require little shielding. Such a prospect should, however, be viewed with caution since the need to supply energy to initiate the reaction may leave a comparatively small net energy gain. It has been suggested, for example, that one cup-full of sea water is potentially equivalent to a mere 5 cup-fulls of petrol. But even on this basis world energy resources are vast.

Manufacture

The broad scope of nuclear engineering is also apparent from the diversity of companies engaged in nuclear work. The membership of the Nuclear Energy Trades Associations' Conference gives some indication of the range of interests. It includes the British Chemical Plant Manufacturers' Association, the British Electrical and Allied Manufacturers' Association, the British Engineers' Association, the Scientific Instrument Manufacturers' Association, and the Water-Tube Boilermakers' Association.

As may be gathered from this list, nuclear engineering involves many of the techniques used in the construction of conventional power stations, but there are others peculiar to nuclear work alone. Unusual materials, zirconium, beryllium, ceramics and liquid metals, for example, call for novel approaches; indeed metallurgy has been described as the key to nuclear development. Special forms of concrete are required for shielding, and the concrete rafts on which reactors are based must be placed to closer tolerances than is normally required in other work. Structures, too, must be of unusual accuracy.

Innumerable other needs call for the services of a wide range of specialists. Thus the ventilation engineer has been required to meet new and stringent standards, since the valuable neutrons necessary to maintain a chain reaction may be absorbed by the smallest quantity of foreign matter that becomes associated with the reactor materials during construction.

Radiation

Before the discovery of fission, the value of radiation was already appreciated. Gamma-rays emitted by radium had proved valuable in cancer therapy; and X-rays, which are fundamentally the same, had served a variety of purposes. With the development of the particle accelerator, and in particular the Van de Graaff machine, another source of radiation became available; for example, at the irradiation laboratory of British Insulated Callender's Cables, Limited, polythene insulation is continuously processed by a 2 million volt Van de Graaff accelerator to give it improved qualities. The building of nuclear reactors has provided another radiation source. When uranium splits on fission, fragments are formed consisting of lighter elements, which lacking the correct balance of protons and neutrons are unstable. In consequence radiation is emitted until the stable configuration is achieved, and this may continue over periods ranging from a fraction of a second to thousands of years (a measure of this period is the half life). The radiation may take several forms depending on the isotope, and by chemically separating the individual fission products from spent reactor fuel convenient radiation sources may be made.

The applications of these sources in industry and elsewhere are legion, and may be divided broadly into radiography or transmission techniques and tracer techniques, though exceptions to this classification no doubt exist. Probably the commonest industrial use of radiation sources is in welding and casting examination, where the radiographic process is similar to X-ray inspection. Owing to the small size of the source, points inaccessible to an X-ray machine can conveniently be examined. Tracer techniques have also achieved widespread use. A small quantity of a radioactive isotope mixed with the normal or stable isotope of the same element (the two being chemically identical) will serve to label the element, which can then be traced, through a chemical process, say, by means of a radiation counter. By this technique, the deterioration of furnace linings has been investigated and the wear of machine parts, leaks and stoppages in pipelines have been detected and the silting of river estuaries studied. Other uses of radioactive isotopes include the measurement of soil moisture, determining the density of steam-water mixtures in boiler tests the cross-linking of polythene plastics, and thickness gauging. Some examples that have recently been proposed are: control of soldered joints in electronic equipment, of plywood bonding, of mixing of colour in textile printing, of mixing uniformity of greases or paints, and of sulphur content in blast furnaces; and the study of wear on the surfaces of space-ships and artificial satellites due to interplanetary dust. From these few examples it will be apparent that radiation techniques offer solutions to a great diversity of engineering problems.

THE ENGINEERING EXHIBITION

MARINE, WELDING AND NUCLEAR ENERGY

First Article

The 21st Engineering Exhibition opens at Olympia, London, this week and closes on Thursday, September 12. This year's sub-title is "Marine, Welding and Nuclear Energy"—the latter subject formally entering the exhibition for the first time. ENGINEERING's *stand is No. 8F on the ground floor of the Grand Hall.*

CONTROLLABLE PITCH PROPELLER

British Polar Engines Limited, Govan, Glasgow, one of the Associated British Engineering Group, are showing on their stand one of their two-stroke direct-reversing marine engines, type M48M, which will develop 1,500 b.h.p. at 300 r.p.m. This particular engine is for the M.V. Susan Constant and will drive through a reduction gear and hydraulic coupling. On the same stand the Controllable Pitch Propeller Company are showing a model of the Lips de Schelde propeller which they are now making in this country. The blades of this propeller are arranged in tandem so as to secure the smallest possible hub diameter and consequently to gain all the advantages of controllable pitch together with a very high efficiency over a wide range of pitch settings and speed. The propeller has been employed in several vessels built on the Continent.

SIMPLE OSCILLOSCOPE

To meet the needs of engineers working on industrial electronic equipment, Bates and Bates Limited, Blackburn-street, Liverpool 19, have produced an industrial oscilloscope—the type 0/50. The main feature of the instrument is its extreme simplicity: there are only two controls.

The time base locks at 25 c.p.s. so that two complete cycles of the 50 c.p.s. supply may be shown on the screen. There are no amplifiers, the signal being applied to the deflection plates through an attenuator. In this way the chopped waves that occur with thyratron or ignitron control are faithfully reproduced.

The oscilloscope is capable of showing direct as well as alternating voltages. This feature is desirable in industrial circuits where control voltages often have direct as well as alternating components in the same circuits.

The unit is provided with a 3 in. screen calibrated in volts. There are two ranges, for both alternating and direct currents, namely 0–250 and 0–400 volts. The instrument has been designed for use with electronic welding controls, electronic motor controls, temperature controllers, and similar circuits using mains frequencies.

METALLIC FLEXIBLE HOSE

Introduced for the purpose of overcoming problems associated with the conveyance of liquids or gases at high pressures between junctions which are initially mis-aligned, move angularly, vibrate, or are exposed to high and low temperatures, between + 800 deg. C. and − 200 deg. C., Plessiflex metallic, seamless flexible hose provides also a solution to problems where difficulties in using rigid piping are encountered. The makers, Power Auxiliaries Limited, Kembrey-street, Swindon, Wiltshire, state that the hose is employed in aircraft, aero-engines, guided missiles, rocket motors and in many industries for such purposes as the conveyance of corrosive chemicals and gas and/or vacuum installations. The construction of the hose is shown in the illustration, Fig. 1. The seamless inside tube is of stainless steel but it appears that "Monel," "Inconel," nickel, copper, aluminium and Tungum-alloy may be used in the future. The strength and flexibility of the tube are due to the helical convolutions adopted and the hose is reinforced by a single or double metallic braid, depending on the working conditions.

The firm have recently supplied to the United Kingdom Atomic Energy Authority a 75 ft. length of stainless-steel convoluted hose having a diameter of 1½ in. This has been specially built to carry mechanical and electrical cables, as well as cooling gas, to a grab/miniature television camera unit recently developed for carrying out the internal inspection of nuclear reactors. Covered with stainless-steel braid, the hose has been constructed in four separate lengths, each joint being arranged to allow the hose to be set at any required angular position.

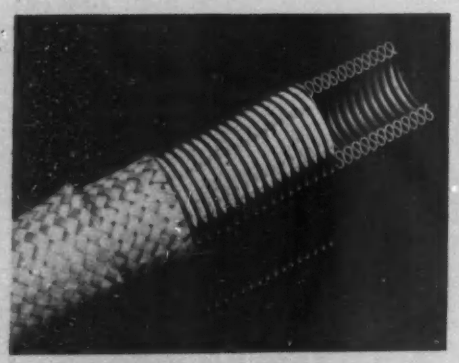


Fig. 1 Plessiflex metallic hose will convey chemicals and gases at high pressures, and at temperatures from − 200 deg. C. to + 800 deg. C. Power Auxiliaries Ltd.

NUT RUNNING

To meet a demand for tightening a large number of nuts simultaneously, the Consolidated Pneumatic Tool Company, Limited, 232 Dawes-road, London, S.W.6, have designed a series of multi-spindle rigs. The rigs, of which examples are displayed at the Engineering Exhibition, are air driven and have been the subject of extensive user research.

The majority of uses have so far been on motor vehicles. The unit shown in Fig. 2 is a ten-spindle tool for running up and tightening bolts on a rear-axle housing cover assembly. The torque required is 4 to 6 lb.-ft. and the air consumption is 85 cub. ft. per min.; the weight is 85 lb. Standard C.P. pneumatic stall torque motors or Hicycle electric motors are used in the units, which can be set to a predetermined torque. Automatic release devices ensure disengagement on the completion of nut running.

Units producing torques up to 115 lb.-ft., and others with up to 12 spindles, have been produced. The company emphasises, however,

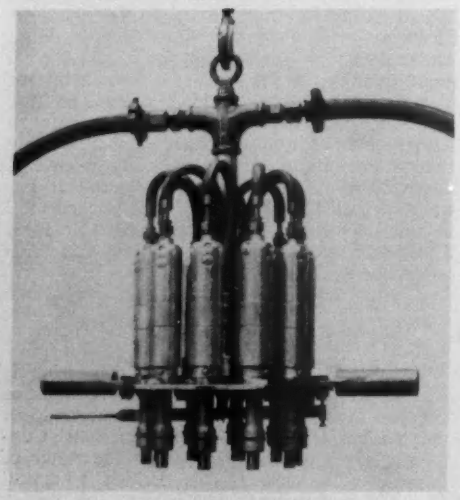


Fig. 2 The ten-spindle tool shown is a pneumatic device for running up and tightening ten bolts on an axle cover simultaneously. Consolidated Pneumatic Tool Co., Ltd.

Things to See at Olympia

Described in this Issue

CONTROLLABLE PITCH PROPELLER
British Polar Engines Ltd.
SIMPLE OSCILLOSCOPE
Bates and Bates Ltd.
METALLIC FLEXIBLE HOSE
Power Auxiliaries Ltd.
NUT RUNNING TOOL
Consolidated Pneumatic Tool Co., Ltd.
GEARBOXES, GEARS AND TRANSMISSIONS
Moss Gear Co., Ltd.
John Holroyd and Co., Ltd.
Opperman Gears Ltd.
E.N.V. Engineering Co., Ltd.
S. E. Opperman Ltd.
Fluidrive Engineering Co., Ltd.
Modern Wheel Drive Ltd.
POWER TRANSMISSION
Crofts (Engineers) Ltd.
GEAR UNITS
David Brown Industries Ltd.
SELF-CHANGING GEARS
Self-Changing Gears Ltd.
ANTI-VIBRATION MOUNTING
Metalastik Ltd.
SPEED GOVERNOR
Bryce Berger Ltd.
FILTER-SEPARATOR UNIT
Automotive Products Co., Ltd.
MARINE DIESELS
Bolinders Co., Ltd.
INDUSTRIAL DIESEL
F. Perkins Ltd.
MULTI-PURPOSE POWER PACKS
Henry Meadows Ltd.
ELECTRIC WELDING EQUIPMENT
English Electric Co., Ltd.
Fuller Electric Ltd.
Lincoln Electric Co., Ltd.
Rockweld Ltd.
Murex Welding Processes Ltd.
SPOT WELDING
A.R.O. Machinery Co., Ltd.
MULTIPLE SPOT WELDING
Bates and Bates Ltd.
AIR AND FOOT OPERATED SPOT WELDERS
Sciaky Electric Welding Machines Ltd.
MANIPULATORS FOR WELDING
Donald Ross and Partners Ltd.
GAS CUTTING
Hancock and Co. (Engineers) Ltd.
British Industrial Gases Ltd.
British Oxygen Gases Ltd.
REACTOR MODELS AND MATERIALS
Newalls Insulation Co., Ltd.
John Thompson Ltd.
General Electric Co., Ltd.
Talbot Stead Tube Co., Ltd.
HEAT EXCHANGERS
Babcock and Wilcox Ltd.
PROTECTIVE GLASS
Pilkington Brothers Ltd.
ISOTOPES AND RADIATION
Gamma-Rays Ltd.
Solus-Schall Ltd.
NO-BREAK STANDBY GENERATOR
Lister-Blackstone Group
CALIBRATED RELAY
Smiths Industrial Instruments Ltd.
HOT-AIR BLOWERS
Service Electric Co., Ltd.
ALTOREG COMPOUNDING
Laurence, Scott and Electromotors Ltd.
UNDERWATER LAMP
Clarke, Chapman and Co., Ltd.
CHANGING COLOUR DIMMING
General Electric Co., Ltd.

To be Described in Subsequent Issues

Other exhibits of special interest include free-piston gasifiers made by several companies (including a complete 350 kW set shown in operation by the Free Piston Engine Company, Limited); two new industrial gas-turbines made by the English Electric Company, Limited (2,950 h.p.) and Ruston and Hornsby Limited (300 kW); new turbo-chargers for Diesel engines up to 400 h.p. shown by the B.S.A. Company, Limited; a hollow ram attachment which gives equal power in both directions, by E. P. Barrus Concessionaires Limited; vacuum work-holding equipment by the Turner Manufacturing Company, Limited; aluminium hatch cover, by Northern Aluminium Company, Limited; a range of heavy forgings by Firth Brown Limited; and a new three-dimensional conveyor, by Metalastik Limited, which is suitable for difficult layouts.

that each job where multi-spindle rigs may be used requires separate consideration. Multi-spindle drilling rigs are also made.

Gearboxes, Gears and Transmissions

Power transmission being of such fundamental importance to engineering it is only to be expected that machinery for this purpose figures largely at the Engineering Exhibition. The visitor will find that he is presented with a complete range of equipment covering stationary, traction and marine applications of every possible size.

The Moss Gear Company, Limited, Tyburn, Birmingham, 24, for example, have on show cut gears in addition to geared motors, worm, helical and bevel gear units and geared couplings, while John Holroyd and Company, Limited, Milnrow, Lancashire, exhibit, among other items, a pair of worm gears which holds the world record for an efficiency of 98·2 per cent., as determined by National Physical Laboratory test. Geared motors, coaxial speed reducers and worm gears are featured by Opperman Gears Limited, Newbury. The E.N.V. Engineering Company, Limited, Hythe-road, Willesden, London, N.W.10, have on exhibition a large range of spiral-bevel, " Zerol," and hypoid gears, including what is believed to be the largest hypoid gear ever produced in this country. Gears and gearboxes for aeronautical and industrial use, together with motorised units, form the principal features on the stand of S. E. Opperman, Limited, Boreham Wood, Hertfordshire.

Fluid couplings of capacities ranging from 0·1 to 20,000 h.p. are represented by the display of sectional and working models shown by the Fluidrive Engineering Company, Limited, Worton-road, Isleworth, Middlesex, and in the large marine gear field a typical exhibit is that of Modern Wheel Drive Limited, Lindo Lodge, Stanley-avenue, Chesham, Buckinghamshire, who feature a four-engine, oil-operated, marine reverse/reduction transmission. This gearbox, which has a ratio of 4·6 to 1, transmits 8,000 b.h.p., that is, 2,000 b.h.p. from each of four Diesel engines.

POWER-TRANSMISSION EQUIPMENT

In addition to a large selection from their range of standard power-transmission equipment, Crofts (Engineers) Limited, Thornbury, Bradford, 3, are exhibiting a number of new items. Current production is typified by a range of clutches, gearboxes, flexible couplings, variable speed drives, conveyor drives and V-rope and chain-power transmission units; the new equipment includes fluid coupling drives, gear units, worm reduction gears, flexible couplings and conveyor drive pulleys.

The new " Hydroflex " drive, which incorporates a vane-type fluid coupling, is made in two basic patterns, direct-coupled for in-line drives, and with a belt pulley for right-angled power take-off by V-belts. It is available at present in a range of sizes up to 133 h.p. A newly-designed dynamometer, the " Airflex," made by Crofts, is used to provide the load on a working demonstration of the fluid coupling, as shown in Fig. 3.

A new series of shaft-mounted gear units comprises 18 sizes, with power outputs up to 120 h.p., with additional features if required. These include a variable-speed combination drive, and the incorporation of shaft-mounted gears with worm gear units to give very high ratios up to 900 to 1. New worm gears include units of 4, 6 and 8 in. centres built to the requirements of the Engineering Equipment Users' Association, and designed to be changed from the standard left-hand assembly to right-hand in a few minutes, without the need for skilled labour. A new flexible coupling, capable of transmitting greatly increased power is also among the exhibits.

A different type of drive, of particular value for portable or exposed installation, is the self-contained belt conveyor drive pulley, which has the complete driving mechanism, electric motor and speed-reduction gearing, housed within the pulley itself. This is available for drives ranging from fractional to 50 h.p., with pulleys up to 40 in. diameter and 80 in. wide. The reduction gearing covers belt speeds ranging from 14 in. to 800 ft. a minute.

GEAR UNITS

The exhibits of David Brown Industries Limited, Huddersfield, cover the whole field of gear manufacture, and include two new items, a combined helical and worm gear unit, and a variable-speed gear. They are shown in Figs. 4 (*a*) and (*b*).

The combined helical and worm unit is designed to accommodate the high torques experienced at low operating speeds, and is available in different types and sizes, with a choice of ratios from 80 to 1, to 250 to 1. It consists of a helical gear first-reduction unit coupled to a standard Radicon worm box, the helical unit being arranged to give a choice of four input shaft positions. This arrangement, coupled with two alternative slow-speed shaft positions, gives a choice of eight different shaft locations. The ratio of the first reduction unit is approximately 4 to 1, the overall ratio being varied according to requirements by the use of different standard ratios in the worm box. Dual-purpose bearings are used in the helical unit, with splash lubrication. Similar bearings are fitted to the worm and wheel shafts of the worm unit, the wheel shaft bearings being heavily rated to deal with overhung loads. An additional roller bearing can be fitted where loads are excessive.

For drives up to 5 h.p. the new " Varicon " variable-speed reducer is now available. It is a hydraulically-operated unit, which gives steplessly-variable output speeds ranging from the original input speed to zero and back again, the full rated load being transmitted all the time. The unit consists of a hydraulic pump and motor, mounted co-axially on opposite sides of a central plate, which distributes the oil to the separate cylinder heads, and takes the reaction of the oil pressure on the pistons. Swash plates operate the pistons axially, and output speed is controlled by a graduated regulator, which effects the required angular displacement of the swash plates.

SELF-CHANGING GEARS

The industrial, rail traction and marine fields are all covered by the exhibits of Self-Changing Gears Limited, Lythalls-lane, Coventry. General industrial applications are represented by the fluid-friction clutch, which combines the fluid and centrifugal types in a single unit, and makes use of the best features of each type. The fluid coupling ensures a smooth take-up from rest, and the centrifugal element provides a positive grip of the friction member at high speeds, although the moving parts are comparatively light. No more space is required for the combined clutch than for the normal fluid coupling.

In the rail traction field the exhibits include the Schneider single-stage torque converter (made under licence from the Schneider Manufacturing Corporation, U.S.A.), an epicyclic reversing unit, and the automatic control for railcar gearboxes which was described in ENGINEERING recently (June 28, p. 829). This latter provides fully-automatic gear selection and engagement, under the control of engine speed, the driver having nothing to do but accelerate,

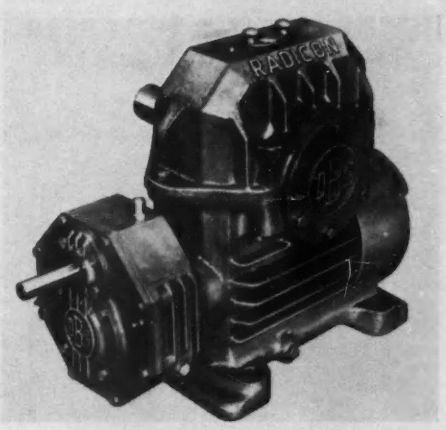


Fig. 4 (a)

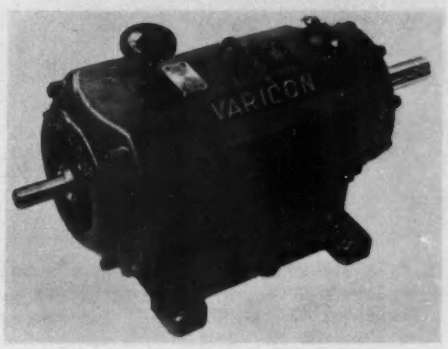


Fig. 4 (b)

Figs. 4 (a) and (b) A combined helical and worm gear box and an infinitely-variable speed reducer designed for powers up to 5 h.p. David Brown Industries Ltd.

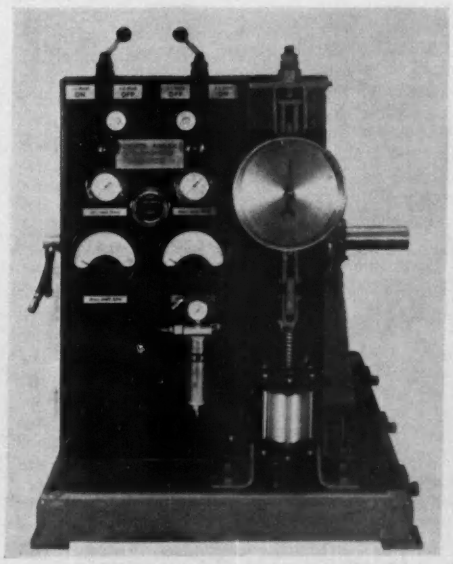


Fig. 3 The " Airflex " dynamometer is used to demonstrate the loading characteristics of a new fluid-coupling drive. Crofts (Engineers) Ltd.

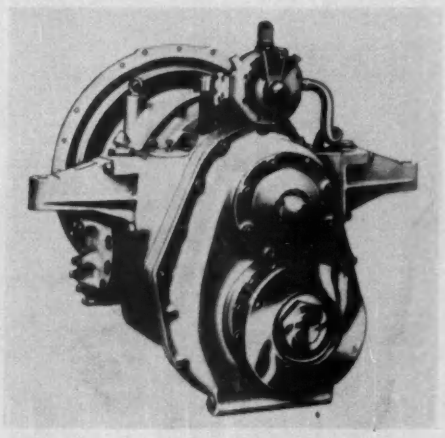


Fig. 5 The " Sequent " self-changing mechanism allows single lever control of engine and gearbox in this marine unit. Self-Changing Gears Ltd.

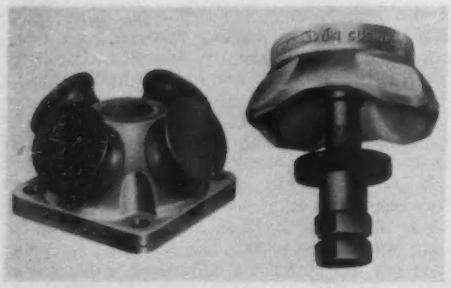


Fig. 6 " Cushymount " anti-vibration mounting for Diesel locomotive engines. On the left the pyramid-shaped base with the four rubber-welded-to-metal springs giving the same flexibility in two planes. On the right the upper cover casting, which fits over the rubber springs, and the bolt with adjustable buffer, controlling vertical and horizontal movement. Metalastik Ltd.

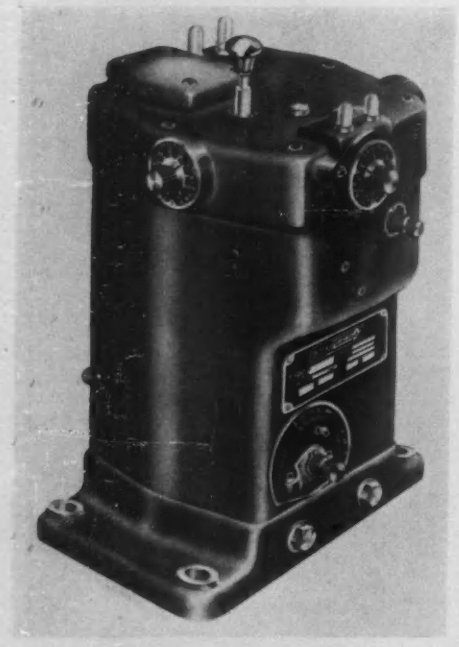


Fig. 7 The Speedlock governor uses a servo system and operates from a hydraulic pump. Bryce Berger Ltd.

decelerate and brake as required. The equipment is based on the Wilson self-changing gearbox made by Self-Changing Gears Limited, and it is possible to convert existing manually controlled boxes to fully-automatic operation.

For marine propulsion work the exhibits include a gearbox for coupling two marine engines to a common output, thus giving the power of a large engine or the economy of a small one, as required. Another unit on show is the oil-operated marine gearbox with " sequent " control which is shown in Fig. 5. This is a compact gearbox designed for unit construction with the engine. It transmits full power ahead or astern as required. The clutches are completely self-adjusting, and a neutral brake is fitted, actuated by oil pressure from the lubrication supply, to ensure a stationary propeller in the neutral position. A novel feature of the box is that the " sequent " gear places the control of both the box and the engine throttle under the same lever. A short movement of the control lever on the bridge engages the gearbox clutch, and a further movement speeds-up the engine to the required r.p.m. The lever can be moved straight from full throttle in one direction to full throttle in the other; the control then operates to reverse the vessel in the shortest possible time.

Diesel Engines

ANTI-VIBRATION MOUNTING

A new design of engine mounting has been adopted for the 34 Bo-Bo Diesel-electric locomotives which are being supplied by the Metropolitan-Vickers Electrical Company, Limited, to Coras Iompair Eireann—the Irish Transport Company. The mounting, known as the Cushymount, is manufactured by Metalastik Limited, Evington Valley-road, Leicester, and it is on view on this company's stand. The mounting has been developed specially for these locomotives but it is designed so that, without alteration in size, suitable characteristics can be obtained for most Diesel locomotive engines.

On the Bo-Bo locomotives a three-point mounting arrangement is employed for the Crossley EST V-8 Diesel engine and the Metropolitan-Vickers generator. A single Cushymount mounting at the engine end of the power unit gives a static deflection of $\frac{1}{16}$ in. under a load of 12,340 lb., while the two mountings supporting the generator each deflect $\frac{1}{16}$ in. under a load of 6,170 lb. Reference to the illustration, Fig. 6, reveals the construction of the mounting, which is shown unassembled. The engine foot casting is seen on the left and the umbrella-like upper casting, to which the engine foot casting is attached, on the right. Circular rubber-bonded-to-metal " sandwiches " are arranged on the four faces of the pyramid-shaped foot casting so as to give the same flexibility in all directions. The sandwiches are loaded in shear and compression to provide both high load-capacity and large deflections. The umbrella-like upper casting to which the engine foot is attached protects the rubber elements from oil and mechanical damage. An adjustable rubber-covered buffer is incorporated in the mounting to maintain vertical deflections within $\pm \frac{1}{8}$in. of the mean laden position while the horizontal movements are limited when the central bolt comes in contact with the impregnated-asbestos ring fitted into the neck of the lower casing.

The Cushymount, as supplied to the Metropolitan-Vickers Company, can be made stiff enough for a deflection of $\frac{1}{16}$ in. under a load of $5\frac{1}{2}$ tons or sufficiently flexible to deflect $\frac{1}{16}$ in. under a load of 1·3 tons. A deflection of $\frac{1}{16}$ in., it is pointed out, gives excellent vibration insulation for frequencies as low as 500 cycles per minute.

The mounting is fastened to the locomotive frame by means of the spigot formed on the lower casting and is secured by four bolts. The upper casting is attached to the engine foot casting with four screws.

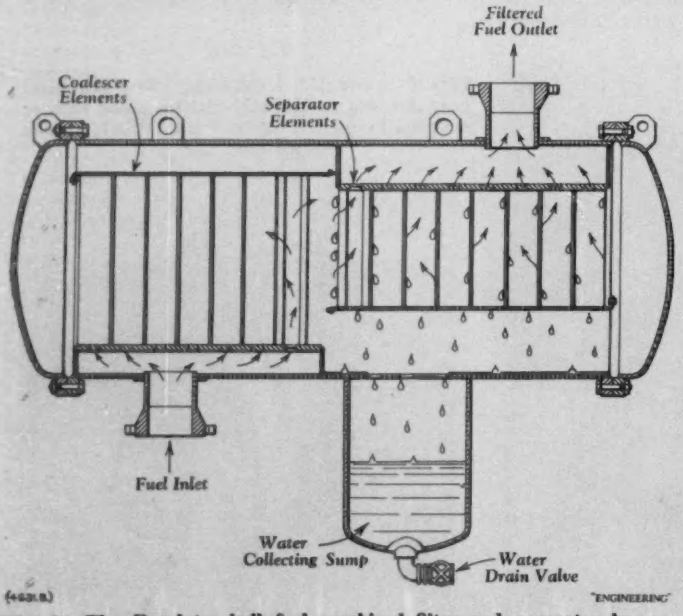


Fig. 8 The Purolator bulk-fuel combined filter and separator has an efficiency of over 99·9 per cent. All water is extracted and all solid particles greater than 5 microns are removed. Flows up to 750 gallons per minute can be handled. Automotive Products Co., Ltd.

SPEED GOVERNOR

A speed governor unit for internal combustion engines is being exhibited by Bryce Berger Limited, Staines, Middlesex. This unit is on show for the first time, and operates on a different principle from most. It is called the Speedlock, and utilises a servo system to supply the governor force. The present model is suitable for engines within the 500 to 5,000 h.p. range. It is hydraulically connected to a gear pump driven by the engine and so can be situated in any convenient location. It is shown in Fig. 7. The operation is that the engine-driven gear pump displaces a hydraulic fluid through a nozzle to impinge against a scoop which is balanced by a spring. Naturally, the faster the engine rotates, the greater the force the jet exerts. Having a very low moment of inertia, the governing response is rapid. A servo amplifier that can be used in conjunction with the control unit, requires a source of hydraulic fluid to provide its motive power, but can draw it from the same source as supplies the governor by placing the nozzle and scoop chamber in tandem with the amplifier circuit. Since the pump is completely divorced from the governor unit, any convenient drive can be used for the former to suit the engine under control.

FILTER-SEPARATOR

On view on the stand of Automotive Products Company, Limited, Leamington Spa, is a new bulk fuel filter-separator, of compact and simple design, introduced by the Purolator Filter Division of the company. Designed in the first place for aircraft fuelling installations, the Purolator filter-separator is equally suitable for use in Diesel fuel-storage depots, large engine test-houses, and dockside installations. It is a compact unit which separates both water and solid particles from the fuel, as indicated in Fig. 8, which shows the disposition of the various filtering elements in relation to fuel flow. Thus, no additional filter is required.

The efficiency of water removal depends to some extent on the operating conditions, but the manufacturers claim that in most circumstances Purolator filter-separators have achieved an efficiency of 99·98 per cent. All solids larger than 5 microns are removed, as well as a large proportion of smaller particles. A range of filter-separators suitable for fuel-flow rates from 250 to 750 gallons per minute will be available.

MARINE DIESELS

Marine engines made by A.B. Götaverken and by Nydquist and Holm A.B. are being exhibited on the stand of Bolinders Company, Limited, 4 Lloyds-avenue, London, E.C.3. Two are models but one is arranged for demonstration running. There are also models of vessels in which Götaverken engines have been fitted. The model Götaverken engine is of the type 630/1300 VGS, an eight-cylinder naturally aspirated engine developing 6,650 h.p. at 125 r.p.m. It is typical of the range from 1,850 to 15,000 h.p. The Nohab Polar model is also of a naturally aspirated type—the MN16—developing 1,140 h.p. at 300 r.p.m. from six cylinders.

The engine that has been arranged for demonstration operation is a supercharged version of the Polar MNI6S which develops 1,640 h.p. at 330 r.p.m. from six cylinders. The range of which this is one, includes engines with from

four to ten cylinders and a range of power in the naturally aspirated condition of from 840 to 2,100 h.p. Bore and stroke are 340 mm. and 570 mm. respectively. All these engines have been well proved in service.

INDUSTRIAL DIESEL

Among the Diesel engines being shown on the stand of F. Perkins Limited, Peterborough, is an industrial version of the P3/144, which has recently been added to their range. It has been introduced to cover manufacturers' and operators' needs for a smaller power unit, particularly for road construction machinery and the lighter types of belt-driven applications. The engine is shown in Fig. 9.

It is a modified version of the P3 Diesel engine which has been in use for some time. The industrial version is a three-cylinder in-line 4-stroke engine, with a bore of 3½ in. and a stroke of 5 in. Its maximum rating is 28·25 h.p. at 1,800 r.p.m. and the maximum torque is 84 lb.-ft. at 1,200 r.p.m. The weight, including the starter motor and air cleaner, but without the flywheel housing and starter unit, is 491 lb. Cylinder block and cylinder head are of high-duty cast-iron, the block being of monobloc construction and integral with the crankcase. High-duty cast-iron liners are fitted. The crankshaft is of chrome-molybdenum steel and the connecting rods of molybdenum steel stampings. Thin-wall big-end bearings are used, lead-bronze lined, and the main bearings are also of the same type. Special cold-starting equipment is included, comprising injector pump, atomiser, priming tank, piping, induction heater and starter heater switch.

MULTI-PURPOSE POWER PACKS

The emphasis at the stand of Henry Meadows Limited, Fallings Park, Wolverhampton (a member of the Associated British Engineering Group) is on the range of multi-purpose generating sets and power mules based on standardised parts and extensive interchangeability. Examples of their marine engines ranging from 90 to 270 b.h.p. are also on display, together with a new engine—the 6DJ.500.

The two ranges of sets are based on six standard engines giving a range from 36 to 270 h.p. or from 22 to 161 kW. Three basic frame sizes are used for mounting. The simplest of the generating sets consists of the engine, an instrument and control panel, radiator and generator mounted on a steel bedplate. Such a set would be used in conjunction with a wall-mounted fuel tank and switchboard. Each succeeding set has more additions until the fifth, the most complete, is entirely self-contained, totally enclosed, and mounted on a trailer to be completely mobile. The power mules are similarly graded.

A wide choice of ancillary equipment is available for the sets including air or hydraulic starting, oil filters and engine protection gear. The illustration (Fig. 10) shows the skid-mounted self-contained version of the 62 kW set with and without its protective canopy.

Welding

ELECTRIC WELDING EQUIPMENT

Every aspect of electric welding, manual and automatic, is represented by the exhibits which can be included under this heading, and there are several new items to be seen. The English Electric Company, Limited, Marconi House, Strand, London, W.C.2, have a new series of electrodes, together with a range of portable welding equipment; Fuller Electric Limited, Fulbourne-road Walthamstow, London, E.17, have projection, flash and arc welding machinery; and the exhibits of the Lincoln Electric Company, Limited, Welwyn Garden City, are featuring, in addition to their range of generating equipment, electrodes and ancillary items, a manual and an automatic welding head, and a traction unit for the automatic head.

Rockweld, Limited, Commerce-way, Croydon, have included in their exhibits a new multi-purpose transformer, the " Autopak " and a new automatic head, the " Autopoint " for use with it. The transformer is a portable unit, with a three-position switch enabling it to serve a single operator, two operators, or the automatic head. The head itself takes wire from reels, with a maximum wire size of $\frac{7}{32}$ in., and a maximum current of 1,300 amperes.

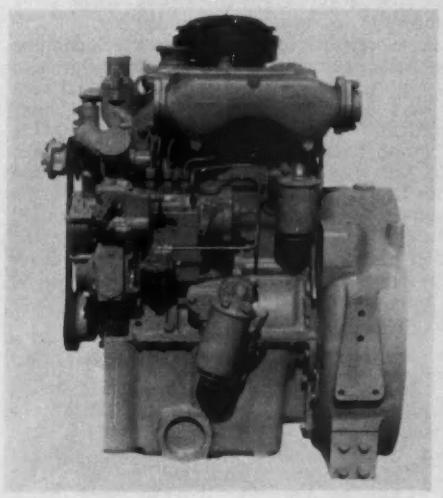


Fig. 9 An industrial version of the P3/144 Diesel engine develops 28·25 h.p. at 1,800 r.p.m. F. Perkins Ltd.

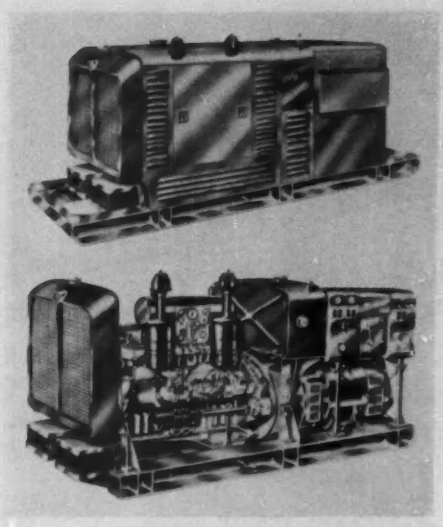


Fig. 10 Multi-purpose power packs and generating sets built from standardised parts. Henry Meadows Ltd.

More than 70 types of electrode, including some new ones, are being shown by Murex Welding Processes Limited, Waltham Cross, Hertfordshire, together with a selection of welding machines and accessories. These include a new automatic arc welding head, the " Muramatic," which has been designed for use either with the open arc process and continuous coated electrodes, or the submerged arc process using powder flux. The welding head (Fig. 11) can be supplied as a separate unit, or it can be mounted on a self-propelled carriage, with infinitely-variable speeds from 8 to 80 in. per minute, and having provision for free steering or track running. The equipment is suitable for either alternating or direct current up to 1,200 amps. All the operator's controls are grouped in a small cabinet close to the welding head; they include a multi-purpose instrument for checking the arc volts and the welding current. Facilities for remote control are also provided.

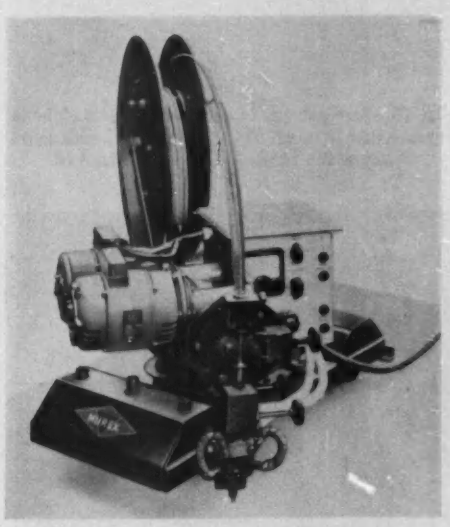


Fig. 11 Among the new electric welding equipment is this automatic welding head, available in several basic types. Murex Welding Processes Ltd.

SPOT WELDING

What is claimed to be the widest range of spot welding guns is being exhibited by the A.R.O. Machinery Company, Limited, 190 Castelnau, London, S.W.13. These guns are classified under three headings, hand-operated air-cooled, hand-operated water-cooled, and automatic water-cooled types. All three types are available in different forms to meet a variety of operational conditions. The hand-operated air-cooled gun, for example, is made in five varieties, to cover light and heavy work, and to operate when great regularity is not necessary, without the automatic timer which is used with all the other A.R.O. guns. Similarly, the hand-operated and the automatic water-cooled guns are arranged to deal with different material thicknesses, and to give different rates of output. All the A.R.O. guns are designed to take numerous lengths and shapes of electrode holders and tips. The accent of the stand is on the " Twinspot " guns, which are of the single-sided approach type, that is, both electrodes approach the work from the same side, so doing away with the necessity for complicated or wide-jaw set-ups. An example is shown in Fig. 12. Suspension details have been improved and all the guns now have a

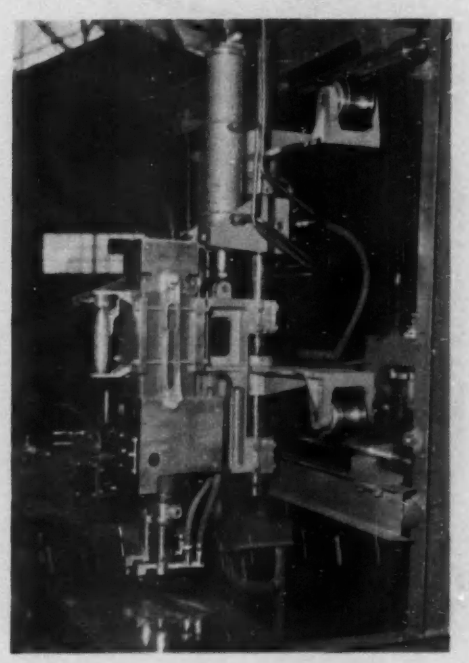


Fig. 12 One of many different types of welding gun, the " Twinspot," is shown here in a special-purpose rig. A.R.O. Machinery Co., Ltd.

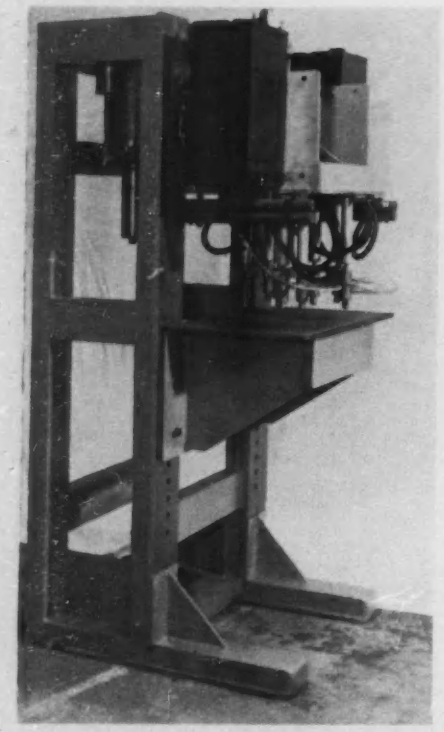


Fig. 13 Any pattern of spot welds up to eight in number can be made on this machine, with hand or automatic feed. Bates and Bates Ltd.

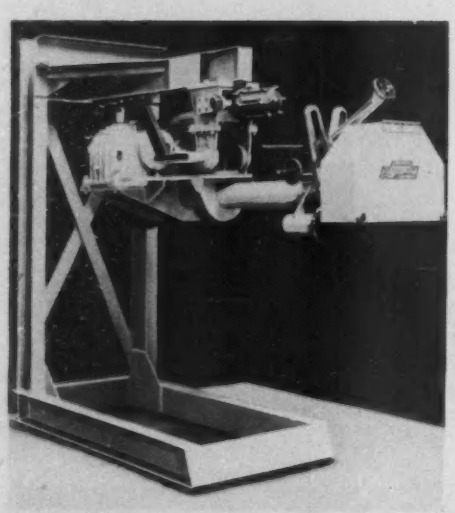


Fig. 14 The Thompson automatic grinding head will dress welds on cylindrical vessels up to 20 ft. long. Donald Ross and Partners Ltd.

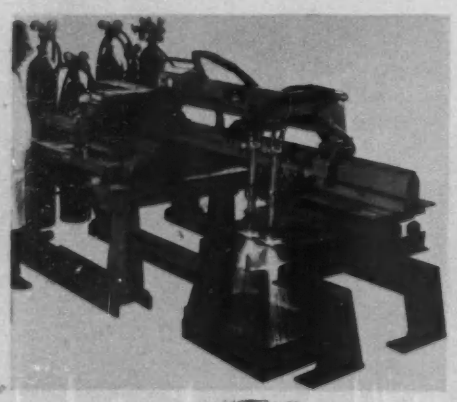


Fig. 15 The "Bison" gas profiler will cut steel up to 12 in. thick, and can have up to three cutting heads. British Oxygen Gases Ltd.

new type of gyroscopic suspension, which gives freedom of movement through 360 deg.

Accessories for use with the guns include some new items, such as a range of pedestals, which can be used to convert the guns into pedestal spot welders comparable with the normal unit machine.

Spring balancers have also been developed, and are now in production. They are fitted with two controls, one allowing the gun to be stopped immediately at any height required, where it remains with 2 ft. of play, while the other control releases the gun from its position and moves it upwards out of the operator's way. A safety brake comes into operation automatically in the event of spring breakage.

MULTIPLE SPOT WELDING

The new 8-spot rack welder included in the display of Bates and Bates Limited, Blackburn-street, Liverpool, 19, is designed round a basic rack type of frame which can have a range of standard fittings mounted on it. One is shown in Fig. 13. Up to eight welds can be made simultaneously from a pair of 45 kVA water-cooled transformers. Easy attachment of standard superstructures for positioning the transformers and electrode holders makes it possible to arrange almost any pattern of weld spots as desired. The top and bottom platens can be of different types, ranging from a simple fixed arm to rotatable three-faced platens or conveyor-type automatic work-feeders. Hydraulic rams of $\frac{1}{2}$ sq. in. bore are used to power the electrode holders; they have an outside diameter of only $1\frac{1}{4}$ in., which permits close spacing, and a stroke of 2 in. A 3 in. forked lug is provided at the top for mounting purposes. Electrode pressure, indicated by a built-in gauge, is adjustable from 150 to 800 lb., higher pressures being obtainable if larger bore cylinders are fitted. Hydraulic pressure is provided by a pressure intensifier, using compressed air at 80 lb. per sq. in. and giving an output of 17 cub. in. at a maximum pressure of 1,600 lb. per sq. in.

A standard range of bottom platens is available. A fixed bed 30 in. by 18 in., with a height adjustment in 2 in. increments may be fitted; alternatively, a rotatable platen with three 20 in. by 18 in. faces is available. This has a hand-screw height adjustment, and is designed for use when jobs are changed frequently. Three different jigs can be fitted to the platen faces, so that at the end of a run on jig No. 1, the platen can be rotated to position No. 2, and the electrode rams adjusted to suit the new work. This can be done quickly with the aid of a template. Electric switches change the electronic controls automatically to the appropriate pre-set values. A further standard unit is the automatic conveyor belt feed. This feeds a flat, plate-type jig holder on to the bottom platen and permits the operator to load and assemble the work well clear of the machine. Finished work is ejected automatically.

AIR AND FOOT OPERATED SPOT WELDERS

Among the welding equipment exhibited by Sciaky Electric Welding Machines, Limited, Falmouth-road (Trading Estate), Slough, are two new spot welders, one for foot and the other for compressed air operation.

The foot-operated machine is of the rocker arm general-purpose type, having an electrical rating of 15 kVA. It has a welding capacity of 14 + 14 s.w.g. mild steel sheet, and greater in unequal thicknesses. The working throat depth is 18 in. Control is through a Sciaky electronic timer, giving a range of weld times from 2 to 150 cycles, and the setting dial is visible and adjustable from the operating station. A stop screw on the pedal bracket provides for instantaneous stroke adjustment up to a maximum of $2\frac{3}{4}$ in. gap. The pedal is radially adjustable and the normal height above the floor level, irrespective of electrode stroke and pressure set, is less than 9 in., which gives a comfortable working position. Generous electrode force is available from a heavy-duty adjustable spring.

Three main sizes of the new air-operated spot welder are available: 15, 25 and 50 kVA nominal rating. All the machines have optional throat dimensions up to a maximum of 36 in. Reduction of setting and maintenance times was one of the major considerations in designing these machines, and all adjustments are capable of being carried out rapidly. Special attention has been given to the accessibility of the main primary current contactor and transformer, in order to speed up routine maintenance. Adjustment of the bottom arm is accomplished by means of a single bolt. Similarly, the timer, a four-channel Sciaky thyratron unit, giving variable "squeeze," "weld," "dwell," and "off" periods, can be removed from the cabinet simply by unplugging it. The timer can also be interchanged between different machine sizes in the "rapid" range. High speed of operation is a feature of the machine; the 15 kVA model, for example, will weld at up to 250 spots per minute.

MANIPULATORS FOR WELDING

The stand of Donald Ross and Partners Limited, Gatwick-road, Crawley, Sussex, is divided into two sections, one of which is used for the display of heavy, boiler works type manipulating equipment, while the other is devoted to a variety of standard positioners. A powered turning roll unit of 225 tons capacity represents a range of positioning equipment which will handle loads of from 2 to 400 tons in weight, and can be supplied in fixed or portable form, with tilting beds, or on self-propelled trolleys.

A new addition to the Ross range of equipment is the Thompson welded seam grinding head. This is designed for removing weld overburden from internal and external longitudinal and circumferential seams in all types of welded vessels. It can be supplied to deal with cylinders up to 20 ft. long and for any internal diameter down to 3 ft. 6 in. It is shown in Fig. 14.

New equipment in the positioner range includes the "Twinner-Aronson" bench-mounted machine. This has 360 deg. rotations to the worktable, work arm and pedestal axis, and all three rotational movements can be locked in any desired position. It is of the balanced type, and will take components up to 100 lb. in weight.

Another new item is the "Twinner" portable power unit, which can be used for rotating cylindrical pipes and vessels from 2 in. to 96 in. diameter during welding or any other operation such as grinding, polishing, painting or flame cutting. In its standard form the power unit will rotate pipes from 6 in. to 30 in. diameter; a special adaptor enables pipes down to 2 in. diameter to be rotated. For dealing with pipes or vessels from 30 in. to 96 in. diameter and up to two tons in weight, a simple turning-roll frame with an adaptor driving pulley is supplied, and the portable power unit is coupled to the pulley.

GAS CUTTING

Developments in gas cutting and profiling are typified on the stands of three exhibitors. Hancock and Company (Engineers), Limited, Progress-way, Croydon, have on display a new pipe-cutting machine, designed for shape-cutting of pipes to prepare them for welding, and a new version of the "Hancoplane" flame planer head. This incorporates an improved method of setting the burners for various types of edge preparation. The burners are mounted on quadrants geared by skew-rack and pinion to a cursor which moves against a large semi-circular dial, each dial being so mounted on back plates that it is capable of slight radial movement. They can be locked in any position. The new head retains the parallel-link type of float which maintains constant burner height in spite of undulations in the plate surface, and includes a pneumatic run-off device to hold up the burner head as it runs off the plate, or to lift it at the end of a cut.

British Industrial Gases Limited, 700 Great

Cambridge-road, Enfield, Middlesex, have on show a new oxygen profile-cutting machine, which is of simple design, and is specially suitable for small engineering works or maintenance shops. They are also exhibiting a new single-stage regulator for use with propane, Pyrogas or Bottogas, for heating and cutting operations. With a maximum flow rate of 500 cub. ft. an hour, and a maximum pressure at the outlet of 15 lb. per sq. in. from a supply pressure of up to 100 lb. per sq. in., the regulator is specially designed for use in heavy industry, or wherever robust construction is an advantage.

Gas cutting and welding over a wide range of applications are featured on the stand of British Oxygen Gases, Limited, Spencer House, St. James's-place, London, S.W.1. Their exhibits include the " Saffire " range of equipment for gas welding, cutting, gouging, heating, flame-cleaning, rivet-washing, and other specialised duties. Hand blowpipes from the same group of apparatus, capable of cutting mild steel up to 12 in. thick are also shown. Cutting machines on display range from a portable machine weighing only 22 lb. to the " Bison " profiler, which will cut steel up to 12 in. thick, and can be supplied with up to three cutting heads. The Bison is illustrated in Fig. 15.

Nuclear Energy

REACTOR MODELS AND MATERIALS

Models are featured by many of the companies concerned with the development of nuclear power. For example, Newalls Insulation Company, Limited, are showing a model of the Chapelcross plutonium plant and power station, which is illustrated in Fig. 16. The main civil engineering contractor for the station is the Mitchell Construction Company, who have supplied the model. Newalls have received from Babcock and Wilcox a contract for the thermal insulation of the 16 stud-tube boilers (or heat exchangers) and associated piping required for this station. Mitchells began work at Chapelcross, near Annan, Scotland, in November, 1955, and are now building the four reactor houses, four 300 ft. high cooling towers, the turbine hall and ancillary buildings, and the sub-station.

The station, which is similar except for layout to the Calder Hall station, will have four gas-cooled graphite-moderated reactors, and is being built for the United Kingdom Atomic Energy Authority. The first reactor is expected to begin operation in 1959 and the other three at six to nine months intervals. The station, which should be fully operative by 1961, will have a total electrical generating capacity of 160 MW.

John Thompson Limited, Wolverhampton, who are associated with the A.E.I.-John Thompson Nuclear Energy Company, are also showing a nuclear power station model—that being built by the group for the Central Electricity Authority at Berkeley. The model represents in section the No. 1 reactor for the Berkeley station, together with its related heat exchangers, and an illuminated circuit shows the course taken by the cooling gas from the reactor to one of the heat exchangers. Other John Thompson exhibits illustrate their work for the Atomic Energy Authority at Dounreay; the company were responsible for the construction of the reactor vessel, heat exchangers and other items for the fast breeder reactor. G.E.C. will also be showing a model of a nuclear power station.

The Talbot Stead Tube Company, Limited, Green-lane, Walsall, likewise include in their exhibit a reactor model—the LIDO swimming-pool reactor at Harwell. In addition they will be showing reactor control rods, charging stand-pipes, flanges in stainless steel, stainless-steel tubes, carbon-steel tubes, bright drawn bars and wire, and turned and ground bars. Talbot Stead have been concerned in the manufacture of items for Calder Hall, Dounreay, and other nuclear installations.

HEAT EXCHANGERS

An important item in a nuclear power station and one that presents many engineering difficulties is the means by which the heat energy of the reactor coolant gas (carbon dioxide in the large British nuclear stations) is transferred to a steam-water circuit; the steam so generated drives a turbine. At Chapelcross, as at Calder Hall, there will be 16 boilers or heat exchangers to achieve this transfer. The construction of all 32 heat-exchange units has been in the hands of Babcock & Wilcox Limited, 209 Euston-road, London, N.W.1, and a sectional model of a single unit, which is on display at the exhibition, is shown in Fig. 17. Prominent on the Babcock and Wilcox stand is a painting representing a large nuclear power station, of the type designed by the Atomic Power Projects Group comprising English Electric, Babcock and Wilcox and Taylor Woodrow. On the reverse of this, is a group of four paintings representing the use of nuclear energy in central power stations, in transportable generating stations and for ship propulsion. Also exhibited is a scale model of a typical welded pressure vessel for a reactor of the pressurised-water type. Associated with this model are samples of a " push-out " formed in 6 in. steel plate and of a weld between very thick plates; indicative of manufacturing techniques required in the construction of reactor pressure vessels.

An adjacent display shows graphically how increases in the designed output and efficiency of a nuclear power station depend on the satisfactory welding of the reactor pressure vessel. Such vessels may require mild steel or alloy plate of greater thickness or higher tensile strength than is normal practice. Samples of nuclear fuel cans and of the finned tubing used in a nuclear heat exchanger are exhibited; and also a model made by the company's research department to assist in building a test loop for the Atomic Energy Authority. The purpose of the loop, which is for insertion in the materials testing reactor DIDO, is to test the effect of in-pile radiation on the aqueous corrosion of water-cooled fuel elements. Another model indicates the possible arrangement of a nuclear propulsion plant, based on a gas-cooled reactor, in the hull of a large tanker.

PROTECTIVE GLASS

Glass as a protective material is the theme adopted by Pilkington Brothers Limited, St. Helens, Lancashire, for their stand at the exhibition. Three kinds of viewing window affording protection against different forms of radiation are being shown. One window measuring 3 ft. 6 in. by 2 ft. 6 in. and comprising one-inch thick stabilised special plate glasses is designed for use in a " hot " laboratory where radioactive materials are handled by means of remotely controlled mechanical hands. A mock-up of a window for Harwell with 36 one-inch thick laminations is illustrated in Fig. 18; the stabilised lead glass has a density of 4·3 gm. per cub. cm.

The protection of medical staff operating a linear accelerator in a hospital is illustrated by a slightly smaller window. Safety from dangerous radiations is provided in this case by 30 one-inch laminations of clear white polished plate glass. A third type of window is in the form of a tank containing a special clear liquid and having at each end one-inch polished plate glass, the inner glass being stabilised against darkening and the outer (the observer's end) being unstabilised. An example of a suitable fluid for this purpose is Shell Ondima oil, a white oil. Pilkington Brothers Limited, are also showing discs of Schlieren plate glass for the observation windows of wind tunnels, laminated thick armour-plate glass as used in submarine escape towers, toughened heat absorbing glass, tinted selective transmission glasses, double windows and glass blocks to provide protection against airborne sound, glass chute and hopper linings to minimise erosion or corrosive wear, and various forms of industrial guard.

ISOTOPES AND RADIATION

The use of radioactive isotopes for weld and casting inspection is already an established

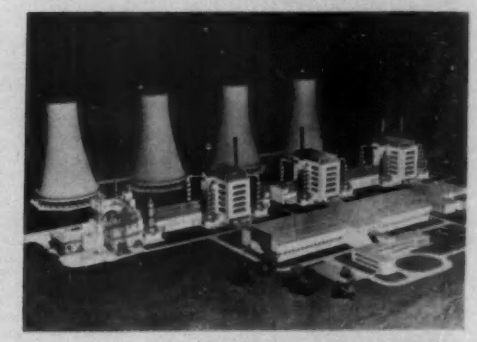


Fig. 16 Model of Chapelcross nuclear power station and plutonium plant. The Mitchell Construction Company have supplied the model, which is being exhibited on the stand of Newalls Insulation Company, Ltd.

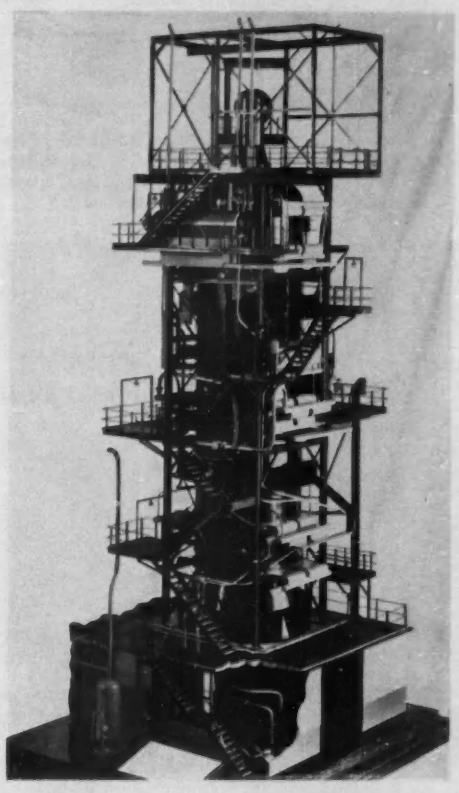


Fig. 17 Model of an 80 ft. high steam-raising tower or heat exchanger for the nuclear power stations at Calder Hall and Chapelcross. Babcock and Wilcox Ltd.

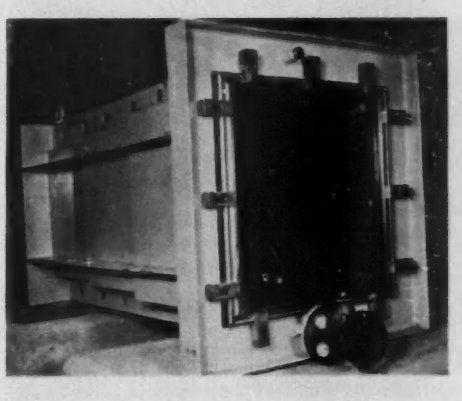


Fig. 18 Protective glass. Mock-up of a viewing window at Harwell comprising 36 1 in. thick laminations of stabilised lead glass. Radioactive materials can be viewed and remotely handled in safety. Pilkington Brothers Ltd.

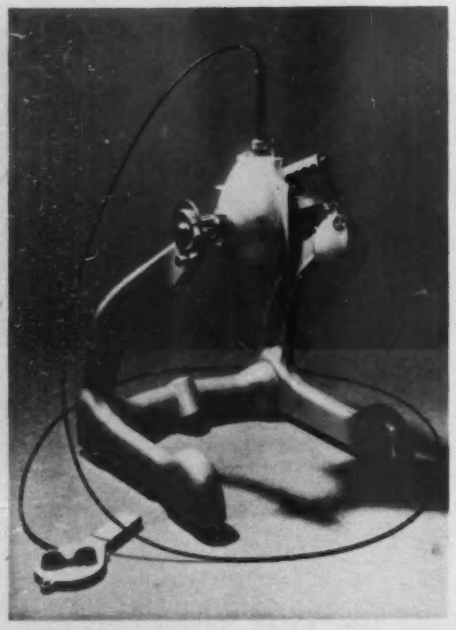


Fig. 19 Isotope container for industrial radiography, model ASS/51. The radioactive isotope is shielded from the operator and can be exposed remotely when required. Gamma-Rays Ltd.

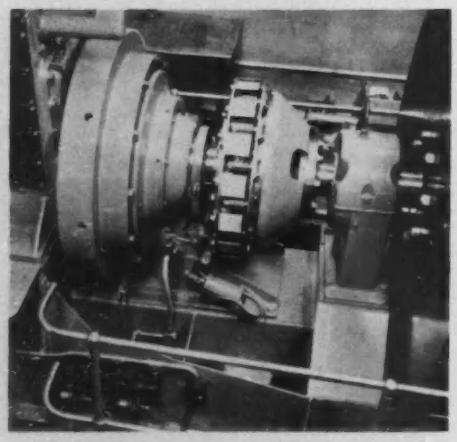


Fig. 20 On the standby generator the flexible coupling located between the flywheel and the engine damps out any harmful torsional vibrations. The generator is to the right of the flywheel. Lister-Blackstone.

Fig. 21 The calibrated relay is equipped with a magnetic lock which ensures that it closes at within 1 per cent. of its set value. Smiths Industrial Instruments Ltd.

practice and devices to contain and expose the isotope by remote control are already becoming familiar. Equipment for industrial radiography employing radioactive isotopes is made by Gamma-Rays Limited, Foundry-lane, Smethwick 40, Staffordshire, who state that their equipment is particularly suitable for applications where the use of X-ray plant is excluded by virtue of its high cost or inaccessibility of the test section. Isotope techniques are also valuable for site work, as in the case of pressure vessels, storage tanks, pipelines, and reactor heat exchangers. The company employs a service department for this purpose, and operates various mobile radiographic units.

The principal exhibit, the model ASS/54, is said to be the largest gamma-radiography machine made in this country, and is designed to contain 20 curies of cobalt 60; it can also be adapted to take 2,000 curies of caesium 137, when these become available for general use. The machine is intended for permanent installation in a radiographic room, but the company also makes a number of smaller models, including the ASS/51. Shown in Fig. 19, the ASS/51 is an operating container for 600 millicuries of cobalt 60 or high strengths of iridium and weighs 84 lb. It is illustrated with remote-control source-protruder attachment fitted, for panoramic examinations where several items disposed around the machine can be scanned in one period.

Gamma-Rays are also showing for the first time their iridium decay clock. The user of several sources of iridium, which has a half-life of 74 days, can set the strength of each consignment immediately on arrival from the U.K.A.E.A. Subsequently the strength of any particular source can be read from scales on the clock, without making any recourse to charts or calculations.

Isotope containers are also among the non-destructive testing equipment being exhibited by Solus-Schall Limited, 18-22 New Cavendish-street, London, W.1. The Solus-Schall model No. 43030 is a tungsten container which, when loaded with 300 milligrams of radium, 300 millicuries of radon, 180 millicuries of cobalt 60, or 360 millicruries of tantalum 182, limits the dose at a distance of one metre to less than 7·5 milliroentgens per hour, the safe figure for a 44-hour working week officially prescribed. The company's lead-filled container, No. 43035, is intended for use with iridium 192, or weak cobalt, radium or tantalum sources.

Electrical Equipment

NO-BREAK STANDBY GENERATOR

The Lister-Blackstone group is exhibiting an 85 kW demonstration unit from a new range of " no-break " alternator sets. The sets come into operation when an electrical power failure occurs, and generate sufficient power to maintain essential services. It is envisaged that the sets will be of value to the requirements of atomic power generation, telecommunications, radar, continuous process industries, etc., that demand a constant source of electrical energy to avoid temporary shut-down losses.

Stand-by power for such installations must be capable of taking over duty without a break. To achieve this, an independent flywheel of substantial diameter and weight is motored by an alternator when mains supply is available. On mains failure, the momentum of the flywheel is sufficient not only to start the stand-by Diesel engine but also to drive the alternator and maintain electrical output in the circuit until the engine takes over.

Fig. 22 By preheating the air by internal circulation, the electric heater can produce higher nozzle temperatures. Service Electric Co., Ltd.

In the set shown, the flywheel is coupled to the driven shaft through a British Twin Disc air-operated friction clutch. A Lister-Blackstone flexible coupling and nodal damper is installed between the clutch and the independent flywheel. The coupling, shown in Fig. 20, absorbs any harmful torsional vibrations in the shafting.

The sequence of operations can be divided into three stages. To start the engine, flywheel, and alternator, air is admitted into the clutch-engaging side of the two pneumatic rams connected to the clutch engagement mechanism. Air is also admitted to the servo reset cylinder of the fuel control rack. Once the clutch is engaged a change-over switch operates the valve controlling the clutch-engaging side of the rams. Air is exhausted from the rams and the fuel rack controller and the engine can be started, using the normal control handwheel.

In stage two the automatic synchroniser with which the set is equipped is switched into the circuit and the motor-operated control of the speed rocking gear—a small type cam—brings the engine speed into synchronism, thus allowing the alternator to be paralleled with the mains supply automatically. The alternator then runs as a synchronous motor driving the independent flywheel and its associated lubricating oil pump.

Two balanced 3-way electromagnetic air valves disengage the clutch and bring the engine to rest. The set is now alerted to act rapidly in the event of a mains failure. On such a failure, the second electromagnetic air valve is de-energised, and the engine started by the flywheel. Resumption of the mains supply causes the automatic synchronising equipment to become operative and close the main circuit breaker. The clutch is disengaged and the engine brought to rest.

CALIBRATED RELAY

A calibrated relay is being exhibited by Smiths Industrial Instruments Limited, North Circular-road, London, N.W.2. The instrument has been designed to maintain and control voltage, current and speed, as applied to starter and overspeed protection. It is suitable for internal combustion engines.

The unit consists basically of a moving-coil system operating in conjunction with a permanent magnet. To ensure that the contacts close at the predetermined value of control current, a patent magnetic lock is used. The lock is adjustable to a predetermined value.

The unit is mounted on a robust metal base, Fig. 21, and is protected by a transparent cover. Under static electrical conditions the relay closes at a value of the control current within 1 per cent. of the value set. A low-power input of about 30 milliwatts is required for closure. Contact pressure is between 15 and 60 grams. The accuracy of setting is not adversely affected by contact wear.

When the relay is open there is a clearance of $\frac{1}{8}$ in. between the contacts. This value is sufficient to prevent closure by vibration. When the relay has been operated, a reduction of the control current by half resets the contacts at open.

HOT AIR

A number of electro-pneumatic devices will be exhibited on the stand of Service Electric Company, Limited, Honeypot-lane, Stanmore, Middlesex. Among them will be a new Secomak heater unit for industrial hot-air blowers. The unit uses a reheat technique to get higher temperatures.

Heat, locally applied, is often required in industrial processes. A convenient source is obtained by using a centrifugal fan to blow air through a specially constructed heating chamber and thence directing it by means of a nozzle or pipe to the required spot. Applications of this

method occur in bottling industries, the sugar coating of pills, and the drying of Wellington boots.

In the new heater, air is preheated by circulating it between concentric tubes before passing it finally over the electric heating element. The maximum nozzle temperature of the re-entrant heater is 900 deg. F., as compared with the 700 deg. F. achieved with previous heaters in the firm's range. Alternatively the same temperature as that of earlier heaters may be obtained, but the loading of the element is reduced by 25 to 30 per cent. A further advantage of the recirculation is the comparative coolness of the outside of the heater.

In Fig. 22 the re-entrant heater is shown. It can be fitted to the outlet of any Secomak blower, or may be used at the end of a pipe or flexible hose. Air at the ambient temperature enters the heater at the left-hand end and hot air is emitted from the nozzle on the right. The diameter of the nozzle shown is ½ in., but the outlet may be anything up to 2 in., and may be fitted with a 2 in. B.S.P. adaptor. Standard loadings are 1, 2, or 3 kW. The weight of the heater is 9 lb.

ALTOREG COMPOUNDING

The usual Diesel-driven alternator met in marine applications is represented on the stand of Laurence, Scott and Electromotors Limited, Gothic Works, Norwich, by a motor-alternator set. The alternator will have "Altoreg" compounding with automatic voltage regulation supplied by a magnetic amplifier. The company claim that the voltage response and regulation of the alternator system is specially suitable for a ship's supply where an alternator of limited capacity may have to supply heavy starting loads.

The basic Altoreg system uses static excitation control equipment in conjunction with an alternator having two field windings. The main field winding is series excited, that is, excited by the load current. This is achieved by the use of rectifiers fed by current transformers in the output circuit of the alternator, in the case of small self-excited machines. Alternatively, the auxiliary field may be excited from a separate direct current source, such as a pilot exciter.

The main connection diagram of a self-excited Altoreg alternator is shown in Fig. 23. Owing to the use of series-connected main excitation, large loads, of the order of up to twice full-load current, can be switched on and off without excessive temporary voltage regulation and with short recovery time, provided that the prime mover has the necessary overload capacity. The inherent steady-state voltage regulation, for a consistent, substantially linear load/speed characteristic of the prime mover, is of the order of ±5 to ±7½ per cent. To obtain higher accuracies, a conventional automatic voltage regulator can be added in the shunt winding of the alternator.

The machines are of the standard salient-pole, rotating armature type. The initial build-up voltage is obtained by a re-connection of the shunt and/or series field windings, usually by a relay.

UNDERWATER LAMP

A new underwater light fitting is shown on the stand of Clarke, Chapman and Company, Limited, Gateshead, County Durham. The fitting is manufactured by E. N. Mackley and Company, Gateshead, County Durham, to a patent of the United Kingdom Atomic Energy Authority.

The lampholder body is of aluminium construction and has a sealed-side cable-gland entry that gives access to the connection of the lampholder. The lampholder is secured in such a way that when the lamp is screwed in position, correct alignment is ensured. In this way contact between the neck of the lamp and its spring-loaded rubber seal is obtained. The system of assembly gives complete water tightness.

The maximum wattage of the lamp is 1,000. A wide-distribution beam is obtained so that the area illuminated depends on the height at which the lamp is suspended. The lamps are in use at Calder Hall, Harwell, and Risley.

To give protection to the lamp under working conditions, an aluminium guard (Fig. 24) is fitted. This has a top grid that allows the passage of light and protects the glass against breakage. The fitting has stainless-steel wing bolts to facilitate stirrup mounting. It can also be secured in position from a cast lug on the lampholder body, if required.

All aluminium parts of the lamp fittings are anodised to prevent corrosion. The structure and water sealing arrangements are suitable for withstanding water pressure experienced at depths down to 1,500 ft.

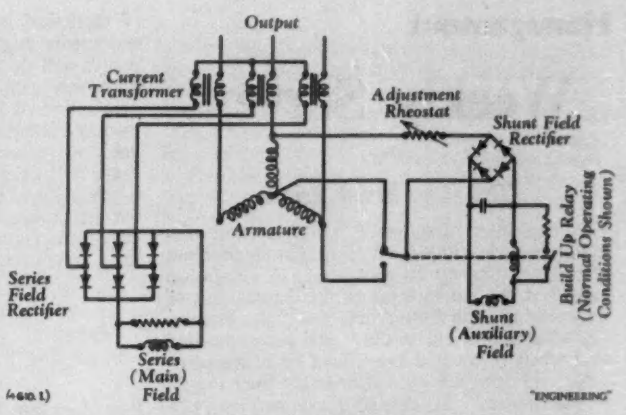


Fig. 23 A self-excited Altoreg compounded alternator has a voltage response and regulation suitable for a ship's supply. Laurence, Scott & Electromotors Ltd.

CHANGING COLOUR DIMMING

A lighting display is being given on the stand of the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2. An electronic dimmer is shown and is illustrated in Fig. 25. The new dimmer is an advance on that installed in the "Empress of England." Whereas a small potentiometer driven by an induction motor regulated dimming in the earlier equipment, an electronic unit does so in the new version. It is shown operating in conjunction with four lines of cold-cathode tubing—red, blue, green, and warm-white. They form an 11 ft. diameter circle in a cornice arranged to light a dome.

The combination of dimming with colour-changing is achieved by relays that connect the control unit successively to three circuits containing tubes of different colours. A direct connection to the mains provides an overlap of colours and a continuously changing illumination can be obtained. Also, additional colours may be added as a background. The same system is applicable to the control of hot cathode tubes and tungsten lamps.

In the control unit the current to the lamps is passed through thyratrons. If the thyratrons conduct through the whole of each cycle of the alternating supply, the illumination is high. Conversely, the tubes may be dimmed by restricting the thyratron conduction periods. When cold cathode tubes are used, as in the exhibition display, they may be operated from normal leakage-flux transformers.

The thyratron valves used to control the dimming are connected in reverse-parallel; so they conduct alternately on successive half-cycles. The period over which the thyratron conducts is controlled by the potential of the grid electrode. In earlier equipment the control of the phase shift of the firing signal, applied to the thyratron grid, was carried out by a rheostat. In the new equipment an all-electronic method is used.

* * *

SWEDISH FAN WORKS COMPANY

In our article on page 617 of our issue of May 17, on "Engineering Firms in the Free Trade Area," we made a passing reference to A.B. Svenska Fläktfabriken, of Stockholm and Jönköping, and added that this firm made electrical precipitation plant, for use in cement and other works, and pneumatic transport equipment. The company have written to us to point out that their manufacturing programme comprises a wide range of air-handling equipment, from very small propeller fans to large and elaborate lumber driers. The firm undertake the ventilation and conditioning of the air in houses, offices, hotels, industrial premises, ships, railway coaches and elsewhere, and the drying and conveying of materials by means of air. They also supply from stock, equipment for air-conditioning, heating and ventilating installations.

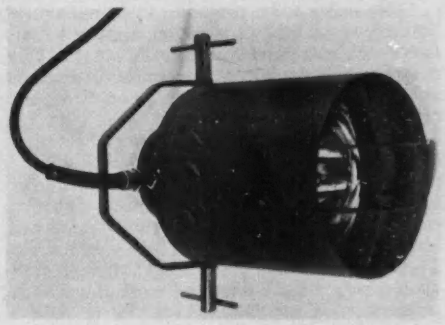


Fig. 24 An underwater lamp which can operate at depths of 1,500 ft. Clarke, Chapman & Co.

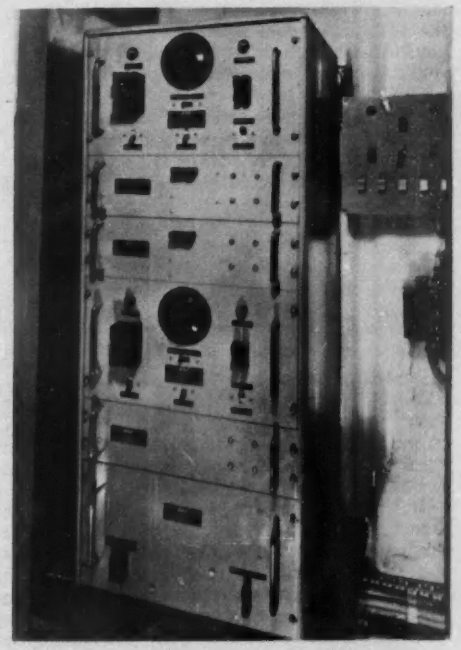


Fig. 25 By combining colour-changing with dimming, continuously changing illumination is obtained. The control unit of an electronic dimmer is shown. General Electric Co., Ltd.

* * *

George Kent Limited, Luton, have recently opened a showroom for process control and measurement instrumentation, on the premises of what used to be their retail shop for domestic machinery. After 119 years of existence, they have finally closed down the domestic-machinery retail side of their business and are concentrating on the industrial instrumentation side.

Management

Weekly Survey

Threat to Fixed Prices

The engineers' merchants, stockists and distributors trade is at present up against the problem of price-cutting by its members. A resolution passed at the last meeting of the Association of Engineering Distributors deplored "the increasing tendency to cut prices" and recommended that when prices had been fixed by a manufacturer and accepted by a distributor they should be maintained. To engage in competitive price cutting, they argued, would ruin the trade. Distributors who cut prices would soon bring about a general demand from manufacturers for a reduction of re-sale margins, and the whole trade would find it exceedingly difficult to provide the facilities and service which justify its existence.

There exists some prejudice in manufacturing industry against the distributors, and the temptation to squeeze margins is already great. There is also much confusion in respect of discounts and trade margins generally. For example, a manufacturer of pumps gives 17½ per cent. plus 5 per cent. to his main distributors, whereas a manufacturer of domestic oil burners gives 40 per cent. Some manufacturers do not quote a selling price but only a trade price (which in effect is a contract price and rarely published), leaving the distributor to fix his own margins. There are thus many instances where margins do not reflect the amount of work done by the distributor. Essentially a margin is paid to finance the holding of stocks, the employment of salesmen and the provision of service. Not all distributors fulfil all these three main functions. For those who do not "sell," or do not provide service, margins may well be too high, and these people can therefore afford to cut prices. But the firms who advertise, have men on the road, employ service engineers—in other words the firms which play their part as distributors fully—need good margins to finance these activities and reasonable profits to plough back for expansion. Price-cutting can only weaken the trade, and few good distributors would dispute the urgent need to raise standards.

★ ★ ★

Industrial Profits

Industry's performance during 1956 was better on the whole than some companies had anticipated. Profit margins were often reduced but most of the leading companies, particularly in the metal and engineering industries, recorded substantial increases in output with a resultant net increase in total profits.

In the field of engineering, the 259 companies which are included in the *Financial Times* analysis of the results of public companies reporting during the first seven months of this year show an increase of about £3 million, to £151·8 million, over the previous year. Iron and steel workers did even better, advancing by over £5 million to £143 million. Shipbuilders also improved their performance, despite frequent and prolonged labour troubles. The two weak spots in the metal-using industries are those concerned with the manufacture of consumer goods. The group of 69 companies labelled "electrical and radio," which includes in most cases a large proportion of electrical machinery and equipment as well as household appliances, made £7 million less than the previous year (£96 million compared with £103 million). The 75 companies in the motor, cycle and aircraft industries showed a reduction of £3 million to £68 million.

It is a pity the chairmen's assessments of future prospects do not lend themselves to this type of statistical analysis. Our weekly review of statements suggests that the majority of companies will do rather better this year than last. Although profit margins are down in most cases, production is rising and the order books of leading companies are very full. In motor vehicles and electrical engineering in particular, there will be a marked improvement. On the whole therefore there would seem little ground for pessimism. As the *Financial Times* points out, "the economy as a whole can be held to have entered a new expansionary phase."

★ ★ ★

Dog Eats Dog

The London Electricity Board's proposal to deliver their own letters need not, perhaps, be taken too seriously. Their chief accountant says that bills could be delivered by their own staff at something below half the Post Office charges. In the London area, with the very high concentration of addresses and with each one being an almost certain customer, it should not be very difficult to secure economies over a rate which is established for the country as a whole. It is unlikely, for example, that the South Western Electricity Board, or the North of Scotland Hydro-Electricity Board, would follow the L.E.B.'s lead. On the other hand, it is hardly surprising that the Eastern Gas Board should feel the same as L.E.B.

This is no new phenomenon. The revolt against monopoly has taken many shapes and directions before. Not many years ago there was quite a furore when certain companies expressed their resentment at being forced to buy the Authority's electricity rather than generate their own. What is different is that the revolt should come from a monopoly. What would be the end of such a campaign, if it ever got going? The Coal Board might make their own gas, the gas boards their own meters, the railways run their own lorries for "special" freight, to say nothing of the G.P.O. turning the scales by generating their own electricity for lighting. Large firms could do the same, and a real free-for-all develop.

It is patently silly to put forward the suggestion, as the L.E.B. did, of delivering letters in a densely populated area without regard to delivery costs elsewhere. The immediate result would be to force the G.P.O. to raise their charges to cover the loss of revenue in a highly profitable area; two men would be doing the job of one and the country would be the poorer for it. Every type of public service carries a kind of social obligation, e.g., to carry people to their work, to deliver mail, to supply water, gas, and electricity, etc., and with it goes the feeling that all citizens should pay the same rate for what they get. This would be politically hard to alter; there are grounds for asserting that it is ethically right. But if the discrepancy between London delivery costs and the G.P.O. charges is so great, why should the L.E.B. or the E.G.B. not bargain for a "contract" price? This is accepted industrial practice, and as such, quite unexceptionable. Although the objections on social grounds would remain, the way forward would be made a little easier.

★ ★ ★

Making the Manager

Text-books on management abound; most are attempts to put across certain rules and principles that have to be followed, generally arising from so-called scientific practice. They have their uses, especially for the student who is seeking a background of knowledge, and for the manager who wishes to sharpen his wits "on the hones of keen minds." But they do not make managers or effectively teach management.

An old hand at the game, Mr. Harold Whitehead, has just written a book on management, but a book with a difference. The title should have been *How I became*, not *How to become a Successful Manager* (Allen and Unwin, 15*s.*). It is a cheerful wittily assembled collection of experiences drawn from the author in his successive capacities of counter hand, shop manager, teacher, consultant and company director. In a foreword, Sir Cecil Weir likens it to an American best-seller of his youth, *The Letters of a Self-made Merchant to his Son*. This title conveys rather well the fatherly, twinkling humour and also a certain ponderousness present in Harold Whitehead's book. Because it is in the first person it reads intimately and easily; this helps the reader to get over occasional irritation when the preaching, or rather the tabulating of essential qualities (how idealistic they seem, but what-the-hell, we manage !) becomes a little oppressive.

This is not the place for a review, nor for an extensive discourse of the Whitehead recipe. He illustrates his points well with accounts of incidents; he drives them home with force and some repetition. To quote Sir Cecil Weir, the book makes the impression of "homely, brisk and sensible advice on matters which are really of the greatest moment in any industrial economy." Perhaps the most usefully taught of all lessons is that "getting management experience comes from the job of doing. But aptitude in doing can be improved immeasurably by further education." Mr. Whitehead did both and is rather good at explaining why it is necessary.

★ ★ ★

Workers Choose Managers

The system of *Mitbestimmung*, i.e. joint management by a wide range of representatives, has now been in operation in the German coal and steel industries for ten years. According to a report published by the German Trade Union Federation it has not been easy to find competent representatives from among the workers themselves. The conditions governing the membership of the supervisory boards (*Aufsichtsrat*) mean that one-fifth of the representatives are independents. Of the rest, however, less than half are actually workers. What no one would have expected is to find that nearly a fifth of the board members chosen by the workers come from the ranks of managers, salaried staff and company directors.

With an open choice the German workers have clearly decided that their interests are likely to be better served by managers, by permanent trade union officials, and a variety of people from outside industry such as civil servants, lawyers, teachers and newspaper editors. While it would be wrong to say that *Mitbestimmung* has been turned by the workers into a tool of management, it has certainly not provided the platform for extremists that many industrialists predicted it would.

★ ★ ★

B.I.M. Award

The President of the Board of Trade, Sir David Eccles, has accepted the award by the Council of the British Institute of Management of an honorary fellowship of the Institute. In a letter to Mr. Harold Wilmot, C.B.E., chairman and managing director of Beyer, Peacock and Company, Limited, and chairman of B.I.M. Council, Sir David writes of "the importance of the rôle which improved management has to play in our affairs. I have followed with interest the progress of the Institute."

Fellowship of the British Institute of Management is the highest of three grades of corporate membership in the new institute formed this year by the integration of B.I.M. with the Institute of Industrial Administration. An honorary fellowship of the Institute is the highest award the Council can offer.

Marketing

LEARNING FROM EXPERIENCE

The publication of the fifth edition of the *CABMA Register* by the Canadian Association of British Manufacturers and Agencies shows how a good idea, when put to the test of the market, can and will evolve into something even better. CABMA are managers for the Dollar Exports Council.

A Canadian business man, Mr. James S. Duncan, who is chairman of the Hydro-Electric Power Commission of Ontario and also of the Dollar-Sterling Trade Council, states in a foreword that the Register "provides concrete evidence of a sustained effort by British industry to retain a larger share of the dynamic Canadian market." He goes on to say that there is every prospect of further gains in British sales which in 1951 amounted to 500 million dols. on the ground that "a continuing high rate of economic development in Canada . . . should bring about a growing and broadening demand for British products."

The other development of importance is brought out in another foreword by Sir William Rootes, chairman of the Dollar Exports Council and of the Rootes Group: "... experience has shown that it (the Register) has proved of greatest value in the field of capital and industrial goods and it has now been decided to confine the Register to the names of British manufacturers of such products and their Canadian distributors." The fact that 3,200 products are listed and that over 3,200 firms give details of their distribution arrangements in Canada is impressive evidence of the scale of the British effort, and should be encouraging to those who are still not there.

★ ★ ★

Best Technical Foot Forward

Traditionally, the British engineering industry has lacked the ability—or the will—to publicise its considerable technical knowledge. More accurately, perhaps, it has not developed the skills required to present technical data in an attractive and convincing manner. The point is made too often and by too many designers and buyers in overseas markets to be ignored or glossed over.

Comprehensive facilities on those lines are not provided by many firms and even the best of advertising agencies find it difficult to cater expertly (in the technical product sense) for the needs of their clients. Studio Irwin Technical Limited are one of the few who specialise in the technical publications side of industry and provide a service for the preparation of brochures, catalogues, instruction handbooks and the like. For this they depend on the work of teams possessing specialised knowledge and skills, to ensure that the technical does not suffer at the expense of publicity and vice versa.

★ ★ ★

Catching Them Young

The growing interest which is being taken by engineering companies in exhibitions designed to appeal to young people is in evidence at the *Model Engineer* Exhibition (see Human Element, page 288); it was also at the Boy Scouts' World Jubilee Jamboree. The Locomotive and Allied Manufacturers Association were prominent exhibitors at the industrial pavilion which formed part of the Jamboree at Sutton Coldfield. They joined with the Atomic Energy Authority, the Central Electricity Authority, the British Transport Commission and the Shipbuilding Conference in making an appeal to the imagination of the representatives of the world's youth—35,000 of them from 84 countries.

The L.M.A. have an unfair advantage in these matters over most others, since Stephenson's "Rocket" will always appeal more than Arkwright's "jenny" or Whitworth's screw-cutting lathe. Yet the steam locomotive took something of a back seat this time: Bagnall; Beyer, Peacock (who could leave out the articulated Beyer-Garratt?); Hunslet; North British; and Vulcan Foundry had steam models on show but some of them also had Diesels. Altogether, steam exhibits accounted for only five of the 16 on show.

★ ★ ★

Success for the Specialist

An unusual attitude these days is to look to specialisation on a narrow front as a commercial asset, particularly in engineering. The chairman, Mr. C. King Woodbridge, of the Dictaphone Company, told his shareholders at the annual meeting held last month that Dictaphone's "unusual success" resulted from their concentration in the field of recording and reproducing sound "without entering into divergent sidelines." The fact that they sold over £10 million worth of equipment last year, 15 per cent. more than in 1955, certainly does not suggest that diversification is required.

It is, perhaps, on marketing that Dictaphone score most heavily. The appointment as managing director of Mr. Donald MacPhail who, according to Mr. Woodbridge, comes to the company "with a fine background of success in the field of selling," further underlines the importance the board attach to an effective sales policy. Service, and the capacity to give it wherever their machines are in use, is a major factor in their progress.

★ ★ ★

Effective Private Shows

The British Timken show held this week is a striking illustration of what local initiative and organising talent can do. This annual feast of rural activities—"a magnificent demonstration of Britain's farming know-how"—originated in a comparatively small peace celebration. It grew steadily in stature and scope and by 1955 became recognised as one of the leading shows in Britain. Thousands of visitors attend it, the best horses and the best riders are there, agricultural machinery and tractors are exhibited, as well as dogs, birds and rabbits. Many sports are prominently featured.

The management's explanation of the show's success is that "it is organised and run by the workpeople and staff of British Timken Limited and they like it." Their chairman, Sir John Pascoe, told his guests at the pre-opening luncheon, that apart from being the "proper thing" to show an interest in sports, it was also good sense as regards marketing. National prestige is a major sales asset, and excellence at sports one of the most popular forms of prestige.

There is little doubt that the show, attended by some 20,000 people, pays handsome dividends to British Timken. It is good internal public relations (one of the purposes is to encourage a working spirit among the employees and their friends) and first-class publicity outside. To ride thus on the popular appeal of sports, even if fortuitously, shows acute business sense.

★ ★ ★

New Combination in Trucks

The latest Anglo-American enterprise in engineering is in works trucks. The Austin Motor Company and Crompton Parkinson, already partners in the production of electric trucks and road vehicles through a jointly owned company, Austin Crompton Parkinson Electric Vehicles Limited, have made an agreement with a United States company, Clark Equipment Company. In 1950, A.C.P.E.V. purchased I.T.D. Limited, a small but active firm marketing petrol and electric trucks under the name of Stacatruc. With its new backing, I.T.D. entered the materials handling business in a big way and became leaders in their field. It has now been agreed that Clark Equipment Company, who are leaders in the industrial-truck field in the United States, should become equal partners with Austin and Crompton in I.T.D.

The combined resources of the three companies make I.T.D. the largest and one of the best equipped of companies in materials handling. Clark patents, designs and technical experience covering fork-lift truck equipment and straddle carriers will be made generally available, as will the marketing resources of all three companies throughout the world.

★ ★ ★

Man Must Measure

The Germans have come to the fore with a quotation of Galileo—"Measure what is measurable, and make measurable what is not yet measurable." This is the introductory sentence to an information sheet on the International Congress and Exhibition of Measuring Instrumentation and Automation (Interkama) which is to be held in Düsseldorf from November 2 to November 10.

As is often the case with German trade promotion efforts, it is stodgy and dull but full of excellent sense. The whole effort of German makers of measuring instruments is being organised in a typically thorough manner. First, it is stated that measuring instruments are more than "mere commercial goods"—they are controllers, supervisors, "replacements for man" and therefore cannot be the subject of just a sales-promotional effort as would be an ordinary exhibition. They are to be the subject of a congress, not an exhibition. This congress will constitute "a platform for common talk between utilisers and manufacturers." Second, leading technical men are in the fore, including Professor Dr.-Ing. Richard Vieweg, president of the Physikalish-Technische Bundesanstalt; Professor Dr.-Ing. T. Kurt Riess, chairman of Farbenfabriken Bayer; Dr.-Ing. Heinz Thörner, president of the central association of the electrotechnical industry. This could be the beginning of a major effort by the German measuring instrument industry at re-gaining leadership in world markets. It is certainly an original and clever manner of attracting the attention of the world's technologists.

★ ★ ★

Progress on I.T.V.

Commercial television is proving a success for those who had the temerity to invest in it. In their second year of operation, Associated Television, serving only London at week-ends and Birmingham in mid-week, have made a profit of £202,000 compared to a loss of £603,000 in their first year. Recent statements by their managing director, Mr. Paul Adorian, suggest that the venture will become really profitable by 1959 but that it would be a mistake to assume that commercial television is likely to become "a gold rush."

Mr. Adorian estimates that an advertising revenue of £35 million is needed for one network and £55 million for two networks if I.T.V. is to do as well as the B.B.C. Yet in 1954, the latest year for which figures are available, Britain spent on all forms of advertising some £260 million. Assuming there has been an increase to £300 million a year, commercial television needs only 18½ per cent. of the total for two networks.

FORTHCOMING EXHIBITIONS AND CONFERENCES

This list, arranged chronologically, appears in the last issue of each month. Events appearing for the first time, and alterations of dates, places, etc., are indicated by an asterisk (*). Particulars of exhibitions and conferences not included below may have appeared in ENGINEERING, *June* 28, *page* 830; *or July* 26, *page* 126. *Organisers are invited to send to the Editor particulars of coming events as soon as arrangements are made.*

Engineering, Marine, Welding and Nuclear Energy Exhibition.—Thurs., Aug. 29, to Thurs., Sept. 12, at Olympia, London, W.14. Organised by F. W. Bridges and Sons, Ltd., Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 0568.

Frankfurt International Fairs.—*Autumn Fair:* Sun., Sept. 1, to Thurs., Sept. 5, at Frankfurt. *Agents:* L.E.P. Transport Ltd., Sunlight Wharf, Upper Thames-street, London, E.C.4. Tel. CENtral 5050.

Leipzig International Fairs.—*Autumn Fair:* Sun., Sept. 1, to Sun., Sept. 8, at Leipzig. *Agents:* Leipzig Fair Agency in Great Britain, 127 Oxford-street, London, W.1. Tel. GERrard 0357.

Sanitary Installation and Heating Technique Exhibition.—Sun., Sept. 1, to Sun., Sept. 8, at Düsseldorf. Organised by the Nordwestdeutsche Ausstellungs-Gesellschaft m.b.H. (NOWEA) Ehrenhof 4, Düsseldorf, Germany.

Czechoslovak Engineering Exhibition.—Sun., Sept. 1, to Sun., Sept. 22, at Brno, Czechoslovakia. Organised by the Chamber of Commerce of Czechoslovakia, Rjna 13, Prague. Information obtainable from the Czechoslovak Commercial Attaché, 6 Upper Belgrave-street, London, S.W.1. (Tel. SLOane 0691); and the British Council for the Promotion of International Trade, 15 Hanover-square, London, W.1. Tel. MAYfair 0073.

Operational Research, International Conference on.—Mon., Sept. 2, to Fri., Sept. 6, at The University, Oxford. Object: to unify and extend the science of operational research. Organised jointly by the Operations Research Society of America, the Institute of Management Sciences, U.S.A., and the Operational Research Society of the United Kingdom. Apply to Dr. Thornton Page, Operations Research Office, 7100 Connecticut-avenue, Chevy Chase, Maryland, U.S.A., or to Mr. B. H. P. Rivett, Operational Research Society of the United Kingdom, 2 Grosvenor-place, London, S.W.1.

Farnborough Flying Display and Exhibition.—Mon., Sept. 2, to Sun., Sept. 8, at Farnborough, Hampshire. Open to the public on Fri., Sat. and Sun., Sept. 6, 7 and 8, only. Organised by the Society of British Aircraft Constructors Ltd., 29 King-street, London, S.W.1. Tel. TRAfalgar 3231.

Utrecht International Trade Fairs.—*Autumn Fair:* Tues., Sept. 3, to Thurs., Sept. 12, at the Croeselaan Site, Utrecht. *Agent:* Mr. W. Friedhoff, 10 Gloucester-place, London, W.1. Tel. WELbeck 9971.

International Union of Geodesy and Geophysics, 11th General Assembly.—Tues., Sept. 3, to Sat., Sept. 14, in Toronto. Held under the auspices of the International Union of Geodesy and Geophysics, 30 Avenue Rapp, Paris, 7e. Apply to the secretary of the Arrangements Committee for Canada: Professor J. A. Jacobs, Geophysics Laboratory, University of Toronto, Toronto 5, Ontario, Canada.

Developments in Textile Research, Conference on.—Wed., Sept. 4, to Fri., Sept. 6, at Boston, Mass., U.S.A. Apply to the Textile Institute, 10 Blackfriars-street, Manchester.

British Association Meeting.—Wed., Sept. 4, to Wed., Sept. 11, in Dublin. Apply to the secretary, British Association for the Advancement of Science, Burlington, House, Piccadilly, London, W.1. Tel. REGent 2109. See also ENGINEERING, June 28, page 805.

Cologne Fairs.—*Autumn Fair: Hardware and Household Goods:* Fri., Sept. 6, to Mon., Sept. 9; and *Clothing and Textiles:* Sun., Sept. 15, to Tues., Sept. 17, at Cologne. *Agent:* Mr. Neven du Mont, 123 Pall Mall, London, S.W.1. Tel. WHItehall 8211.

British Trade Fair and Exhibition.—Fri., Sept. 6, to Sun., Sept. 22, in Helsinki, Finland. Sponsored by the Federation of British Industries, the London Chamber of Commerce and the Finnish-British Trade Association. Supported by the Governments of Finland and the United Kingdom. Organised by British Overseas Fairs Ltd., 21 Tothill-street, London, S.W.1. Tel. WHItehall 6711.

American Chemical Society, 132nd Meeting.—Sun., Sept. 8, to Fri., Sept. 13, in New York. Organised by the Society, 1155 Sixteenth-street, Washington 6, D.C., U.S.A.

Vienna International Fairs.—*Autumn Fair:* Sun., Sept. 8, to Sun., Sept. 15, in Vienna. *Agents:* British Austrian Chamber of Commerce, 29 Dorset-square, London, N.W.1. Tel. PADdington 7646.

Commonwealth Mining and Metallurgical Congress, Sixth.—Sun., Sept. 8, to Wed., Oct. 9, at Vancouver, British Columbia, and other centres in Canada. Apply to the congress secretary, 507 Metropolitan Building, 837 West Hastings-street, Vancouver 1, B.C., Canada.

Aeronautical Conference, Sixth Anglo-American.—Mon., Sept. 9, to Thurs., Sept. 12, at Folkestone. Organised by the Royal Aeronautical Society, 4 Hamilton-place, London, W.1. Tel. GROsvenor 3515.

Traction Meeting and Production Forum.—Mon., Sept. 9, to Thurs., Sept. 12, at Milwaukee, Wis., U.S.A. Organised by the Society of Automotive Engineers, 485 Lexington-avenue, New York 17.

American Mining Congress, Annual Convention.—Mon., Sept. 9, to Thurs., Sept. 12, at Salt Lake City, Utah. Organised by the American Mining Congress, Ring Building, Washington 6, D.C., U.S.A.

Nuclear Structure, International Conference on.—Mon., Sept. 9, to Fri., Sept. 13, at Rehovoth. Sponsored by the International Union of Pure and Applied Physics. Apply to Dr. Amos de Shalit, Weizmann Institute of Science, Rehovoth, Israel.

Instrument-Automation Conference and Exhibit, 12th Annual.—Mon., Sept. 9, to Fri., Sept. 13, in the Cleveland Auditorium, Cleveland, Ohio, U.S.A. Organised by the Instrument Society of America, 313 Sixth-avenue, Pittsburg 22, Pa., U.S.A.

Macromolecular Chemistry, International Symposium on.—Mon., Sept. 9, to Sun., Sept. 15, at Prague. Offices of the congress: 5 Technicka, Prague 6, Czechoslovakia.

Radio Isotopes in Scientific Research, International Conference.—Mon., Sept. 9, to Fri., Sept. 20, in Paris. Organised by the United Nations Educational, Scientific and Cultural Organisation. Apply to the United Kingdom National Commission for Unesco, Ministry of Education, Curzon-street, London, W.1. Tel. MAYfair 9400.

Food, Cookery and Catering Trades Exhibition.—Tues., Sept. 10, to Sat., Sept. 21, at the City Hall, Deansgate, Manchester. Organised by Provincial Exhibitions Ltd., City Hall, Deansgate, Manchester. Tel. Deansgate 6363.

***British Mathematical Colloquium.**—Wed., Sept. 11, to Fri., Sept. 13, at The University, Nottingham. Apply to Mr. M. E. Noble, Mathematics Department, The University, Nottingham. Tel. Nottingham 45511.

Marseilles International Fair, 33rd.—Sat., Sept. 14, to Mon., Sept. 30, at Marseilles, France. *Agents:* Butler's Advertising Service, 22 St. Giles High-street, London, W.C.2. Tel. TEMple Bar 8905.

Royal Aeronautical Society's Garden Party.—Sun., Sept. 15, at Wisley Aerodrome, near Weybridge, Surrey. Organised by the Royal Aeronautical Society, 4 Hamilton-place, London, W.1. Tel. GROsvenor 3515.

Co-ordination Chemistry, International Conference on.—Sun., Sept. 15, to Fri., Sept. 20, at Rome. Organised by the Italian Chemical Society, Via Quattro Novembre 154, Rome.

Ship Hydrodynamics, International Conference on.—Sun., Sept. 15, to Mon., Sept. 23, at Madrid. Apply to Dr. M. L. Acevedo, Director, Canal de Experiencias Hidroinamicas, Ministerio de Marine, El Pardo, Madrid, Spain.

European Machine Tool Exhibition.—Sun., Sept. 15, to Tues., Sept. 24, at Hanover. Applications for space may be made to the Machine Tool Trades Association, Brettenham House, Lancaster-place, London, W.C.2 (Tel. TEMple Bar 3606). Other inquiries should be sent to Schenkers Ltd., 13 Finsbury-square, London, E.C.3. Tel. METropolitan 9711.

***Institute of Metals Autumn Meeting.**—Mon., Sept. 16, to Fri., Sept. 20, in Glasgow. Apply to the Institute of Metals, 17 Belgrave-square, London, S.W.1. Tel. BELgravia 3291.

Aviation, Medicine, Second European Congress on.—Mon., Sept. 16, to Wed., Sept. 18, at Stockholm. Apply to Dr. Olle Höök, secretary-general to the Congress, Flygvapnet, Stockholm 80, Sweden.

Engineering Education and Training, Third International Conference on.—Mon., Sept. 16, to Fri., Sept. 20, at Paris. Organised by the Engineers' Council for Professional Development, College of Engineering, New York University, New York 53.

Business Efficiency Exhibition.—Mon., Sept. 16, to Sat., Sept. 21, in Cape Town. Organised by the Cape Town Junior Chamber of Commerce, P.O. Box 204, Cape Town, South Africa.

Interaction in Ionic Solutions, General Discussion on.—Tues., Sept. 17, to Thurs., Sept. 19, at the University Laboratory of Physiology, South Parks-road, Oxford. Organised by the Faraday Society, 6 Gray's Inn-square, London, W.C.1. Tel. CHAncery 8101.

Association of Public Lighting Engineers, Annual Conference.—Tues., Sept. 17, to Fri., Sept. 20, in the Town Hall, Torquay. Exhibition of street lighting apparatus and an open-air display of lamp columns and tower wagons in the Upton Valley Gardens. Organised by the Association of Public Lighting Engineers, 17 Victoria-street, London, S.W.1. Tel. ABBey 4281.

Watch and Jewellery Trade Fair, Third International.—Thurs., Sept. 19, to Wed., Sept. 25, at the Royal Albert Hall, London, S.W.7. Organised by Trade Fairs and Promotions Ltd., Drury House, Russell-street, London, W.C.2. Tel. TEMple Bar 3422.

Handicrafts, Homecrafts and Hobbies Exhibition, Fifth International.—Thurs., Sept. 19, to Sat. Sept. 28, at Earl's Court, London, S.W.5. Apply to the exhibition's organiser, 24 Store-street, London, W.C.1. Tel. MUSeum 9792.

Motor Exhibition, International.—Thurs., Sept. 19, to Sun., Sept. 29, at Frankfurt. *Agents:* L.E.P. Transport, Ltd., Sunlight Wharf, Upper Thames-street, London, E.C.4. Tel. CENtral 5050.

***Petroleum Mechanical Engineering Conference, 12th Annual.**—Sun., Sept. 22, to Wed., Sept. 25, at the Mayo Hotel, Tulsa, Oklahoma, U.S.A. Organised by the American Society of Mechanical Engineers, 29 West 39th-street, New York 18. Apply to Mr. Carl A. Stevens, 1932 North Boston-avenue, Tulsa 6, Oklahoma, U.S.A.

***Standards Engineers Society, Sixth Annual Meeting.**—Mon., Sept. 23, to Wed., Sept. 25, at the Hotel Commodore, New York. Apply to the Standards Engineers Society, P.O. Box 281, Camden 1, N.J., U.S.A.

Automatic Measurement of Quality in Process Plants.—Mon., Sept. 23, to Thurs., Sept. 26, at University College, Swansea. Organised by the Society of Instrument Technology, 20 Queen Anne-street, London, W.1. Tel. LANgham 4251. See ENGINEERING, May 31, page 682.

Fisheries Trade Fair, Second International.—Fri., Sept. 27, to Sun., Oct. 6, in the Exhibition Hall Forum, Copenhagen, Denmark. *Agents:* John E. Buck & Co., 47 Brewer-street, Piccadilly, London, W.1. Tel. GERrard 7576.

Stationery and Office Equipment Show.—Sat., Sept. 28, to Wed., Oct. 2, at the Conrad Hilton Hotel, Chicago. Organised by the National Stationery and Office Equipment Association, 750 Investment Building, Washington, D.C., U.S.A.

Perth Royal Agricultural Show.—Sat., Sept. 28, to Thurs., Oct. 3, at Perth. Organised by the Royal Agricultural Society, 9 Howard-street, Perth, Western Australia.

German Brewery and International Beverage and Catering Equipment Exhibition.—Sat., Sept. 28, to Thurs., Oct. 10, in Munich. *Agent:* Mr. M. Neven du Mont, 123 Pall Mall, London, S.W.1. Tel. WHItehall 8211.

Brewers' and Allied Traders' Exhibition.—Mon., Sept. 30, to Fri., Oct. 4, at Olympia, London, W.14. Organised by Trades, Markets and Exhibitions Ltd., 623 Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 1371.

Canadian National Material Handling Show and Conference.—Mon., Sept. 30, to Fri., Oct. 4, at Montreal. Communications to Mr. E. Dupre, Northern Electric Co. Ltd., 150 Metropolitan Boulevard, Lachine, Quebec, Canada.

***Dairy Show, 71st Annual.**—Tues., Oct. 22, to Fri., Oct. 25, at Olympia, London, W.14. Organised by the British Dairy Farmers' Association, 17 Devonshire-street, London, W.1.

***Scientific Instrument Manufacturers' Association (SIMA), Sixth Annual Convention.**—Thurs., Oct. 24, to Sun., Oct. 27, at Eastbourne. Theme: "Enterprise 1958." Organised by the Association, 20 Queen Anne-street, London, W.1. Tel. LANgham 4251.

***Library Services in Technical Colleges, Conference.**—Wed., Oct. 30, at Connaught Rooms, Great Queen-street, London, W.C.2. Organised by Aslib, 4 Palace-gate, London, W.8. (KNIghtsbridge 0444.)

***Materials Handling Convention.**—Mon., Oct. 28, to Wed., Oct. 30, at Leamington Spa. Organised by the Institution of Production Engineers, 10 Chesterfield-street, London, W.1. Tel. GROsvenor 5254.

***National Management Conference.**—Wed., Nov. 6, to Fri., Nov. 8, at Bournemouth. Theme: "Research—A Signpost to Better Management." Organised by the British Institute of Management, 80 Fetter-lane, London, E.C.4. Tel. HOLborn 3456. See also ENGINEERING, August 2, page 133.

***Special Libraries Association, Metals Division Meeting.**—Wed., Nov. 6, to Fri., Nov. 8, in Chicago, Ill., U.S.A. Apply to Alvina Wassenberg, Kaiser Aluminum and Chemical Corporation, Department of Metallurgical Research, Spokane 69, Washington, U.S.A.

***Developments in Industrial Low Temperature Gas Separation, One-Day Conference.**—Tues., Nov. 26, at the Royal Institution, 21 Albemarle-street, London, W.1. Organised jointly by the Low Temperature Group of the Physical Society and the Institution of Chemical Engineers. Apply to the Physical Society, 1 Lowther-gardens, South Kensington, London, S.W.7. Tel. KENsington 0048.

***Problems of Aircraft Production, Sixth Annual Conference.**—Thurs. and Fri., Jan. 2 and 3, 1958, at The University, Southampton. Theme: "United States and United Kingdom Practice." Organised by the Southampton Section of the Institution of Production Engineers, 10 Chesterfield-street, London, S.W.1. Tel. GROsvenor 5254.

***Developments in Foundry Technology, Symposium.**—Wed., Feb. 5, to Sat., Feb. 8, 1958, at Jamshedpur. Organised by the National Metallurgical Laboratory, Council of Scientific and Industrial Research, Jamshedpur 7, India.

***Non Destructive Testing of Materials, Course on.**—Sun., Feb. 9, to Sat., Feb. 22, 1958, in London and the provinces. Fee £42. Organised by the British Council. 65 Davies-street, London, W.1 (Tel. GROsvenor 8011), for people from overseas.

***Gas Turbine Conference and Exposition, International.**—Tues., Mar. 4, to Fri., Mar. 7, 1958, at the Shoreham Hotel, Washington, D.C. Organised by the Gas Turbine Power Division, American Society of Mechanical Engineers, 29 West 39th-street, New York 18.

***Nuclear Congress.**—Sun., Mar. 16, to Fri., Mar. 21, 1958, at Chicago, Ill., U.S.A. Organised by the American Institute of Chemical Engineers, 25 West 45th-street, New York 26. Apply to the Engineers' Joint Council, 29 West 39th-street, New York 18. See also ENGINEERING, August 25, page 219.

***Japan International Trade Fair.**—Sat., April 12, to Sun., April 27, 1958, at Osaka. Apply to the Japan International Trade Fair Commission, Honmashi-bashi, Higashi-ku, Osaka, Japan. See also ENGINEERING, July 5, page 27.

***Radio Component Show, 15th Annual.**—Mon., April 14, to Thurs., April 17, 1958, at Grosvenor House and Park Lane House, Park-lane, London, W.1. Annual private exhibition organised by the Radio and Electronic Component Manufacturers' Federation, 21 Tothill-street, London, S.W.1. (Tel. ABBey 4226.) No special preview will be held on this occasion. Applications for admission must be made in advance.

***Factory Equipment Exhibition.**—Mon., April 14, to Sat., April 19, 1958, at Earl's Court, London, S.W.5. Theme: "Modern Factory Equipment—Britain Challenges the World." Organised by Factory Equipment Exhibitions Ltd., 4 Snow-hill, Holborn-viaduct, London, E.C.1. Tel. CENtral 0354.

Production Exhibition.—Mon., May 12, to Wed., May 21, 1958, at Olympia, London, W.14. Organised by the Institution of Production Engineers. Apply to exhibition Offices: 32 Millbank, London, S.W.1. Tel. TATe Gallery 8134.

***Solid State Physics in Electronics and Telecommunications, International Conference.**—Mon., June 2, to Sat., June 7, 1958, at The University, Brussels. Apply to the honorary general secretary, Société Belge de Physique, Loveral, Belgium.

High Tension Networks, International Conference on.—Wed., June 4, to Sat., June 14, 1958, at Fondation Berthelot, 28 Rue Saint Dominique, Paris. Organised by the Conférence Internationale des Grands Réseaux Electriques (C.I.G.R.E.). Apply to the secretary, British National Committee, Thorncroft Manor, Dorking-road, Leatherhead, Surrey. Tel. Leatherhead 3423.

Automation Exposition and Congress, Fourth.—Mon., June 9, to Fri., June 13, 1958, in New York. Organised by Richard Rimbach Associates, Management, 845 Ridge-avenue, Pittsburg 12, Pa., U.S.A.

British Electrical Power Convention.—Week commencing Mon., June 16, 1958, at Brighton. Theme: "Electricity and World Progress—Britain's Contribution." Organised by the British Electrical Power Convention, Eastcastle-street, London, W.1. Tel. MUSeum 4040.

***Chemical and Petroleum Engineering Exhibition.**—Wed., June 18, to Sat., June 28, 1958, at Olympia, W.14. Organised by F. W. Bridges and Sons, Ltd., Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 0568.

***Iron and Steel Institute Special Meeting in Belgium and Luxembourg.**—Wed., June 18, to Sat., June 28, 1958, at Brussels, Charleroi, Liége, and Luxembourg. Organised by the Iron and Steel Institute, 4 Grosvenor-gardens, London, S.W.1. Tel. SLOane 0061.

***Organisation of Chemical Engineering Projects, Symposium.**—Tues., June 24, to Thurs., June 26, 1958, at Olympia, London, W.14. Organised by the Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. Tel. BELgravia 3647.

Steric Effects in Conjugated Systems, Symposium.—Tues., July 15, to Thurs., July 17, 1958, at Hull. Organised by the Chemical Society, Burlington House, Piccadilly, London, W.1. Tel. REGent 0675.

***High Polymers, International Conference.**—Mon., July 21, to Thurs., July 24, 1958, at The University, Manchester 13. Organised by the Conference Secretariat, Department of Scientific and Industrial Research, 5-11 Regent-street, London, S.W.1. Tel. WHItehall 9788.

Combustion, Seventh International Symposium on.—Thurs., Aug. 28, to Wed., Sept. 3, 1958, at Oxford University, and the Royal Institution, Albemarle-street, London, W.1. Organised by the Combustion Institute, 936A Union Trust Building, Pittsburg 19, Pa., U.S.A. Communications to The Combustion Institute Committee, c/o The Institute of Fuel, 18 Devonshire-street, London, W.1. Tel.: LANgham 7124.

***Future of Non Ferrous Mining in Great Britain and Ireland, Symposium.**—September, 1958, in London. Sponsored jointly by the Institution of Mining and Metallurgy and the United Kingdom Metal Mining Association. Apply to the Institution of Mining and Metallurgy, 44 Portland-place, London, W.1.

Design

LIMITED LIFE DESIGN: A SURVEY OF THE PROBLEM

By J. A. Pope, D.SC., WH.SCH., M.I.MECH.E., *B. K. Foster*, B.SC., D.I.C., *and N. T. Bloomer*, PH.D.

Concluded from page 241

So far consideration has been given to the case where a large number of experimental results have been available for determining the frequency distribution curves for specimens failing by fatigue. In these cases the true mean $\bar{X}$ and the true standard deviation σ could be well approximated. Generally, however, $\bar{X}$ and σ are not known and it is necessary to consider with what confidence $\bar{x}$ and s, obtained from a limited number of tests, may be used. As would be expected, the degree of confidence decreases as the number of test results available decreases. Suppose that only one test result is available. Before this can be used for design it must be decided where it is safe to suppose that it lies with regard to the true mean; on the average, of course, it will lie at the true mean, but it is necessary to be pessimistic and assume its value is high. Clearly with only one result the values of $\bar{X}$ and σ cannot be deduced. It is necessary, therefore, to choose a value of σ. This can only be done by using practical experience gained by considering similar types of experiments already carried out, and it is on this point that a great deal more research is needed.

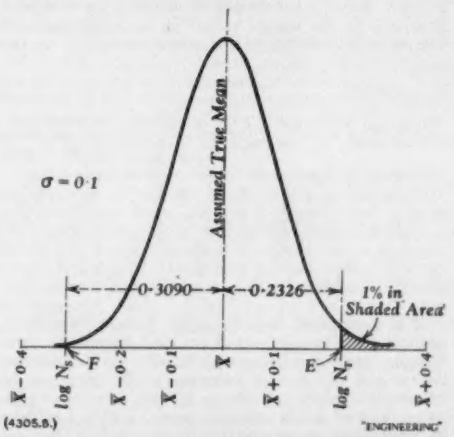


Fig. 25 Probable frequency distribution of cycles likely to bring about a fatigue failure at a given stress, based on the requirement that the one single test result, E, will enable components to be designed with a "99 per cent. confidence" that they will be safe. The standard deviation is taken as 0·1. Point F locates the component for which the probability of failure is 1 in 1,000.

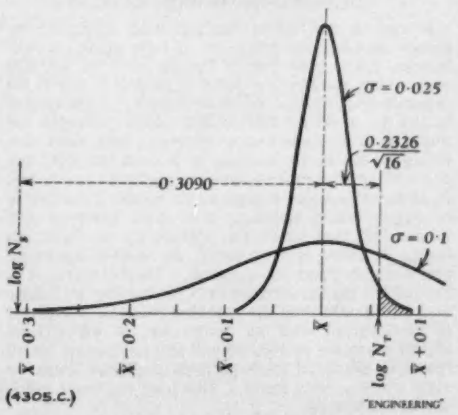


Fig. 26 If 16 test results are available (instead of 1 as in Fig. 25) the acceptable standard deviation is reduced to 0.025 $\left(=\frac{0.1}{\sqrt{16}}\right)$ and, for the same degree of confidence, the component life is increased by 50 per cent.

CASE WHEN ONLY A FEW TEST RESULTS ARE AVAILABLE

In the case of one test result it is necessary to decide on two things: (1) the value of σ for the distribution curve applicable for the component under consideration, and (2) the confidence required in the predictions. The conception of confidence is difficult. Without testing an infinite number of specimens it is never possible to have 100 per cent. confidence in any conclusions obtained. However many tests are carried out there is always some chance that these are not typical results, although clearly the chance of testing all weak, or all strong, specimens is reduced as the number of tests increases.

For the purpose of the following example σ is taken as 0·1 with a lognormal distribution and 99 per cent. confidence in the result is required. To obtain 99 per cent. confidence it is necessary to assume that the single test result (N_T reversals) obtained lies among the strongest 1 per cent. of all the possible results. In this case the value of

$$\log N_T = \bar{X} + 2{\cdot}326\sigma = \bar{X} + 0{\cdot}2326.$$

If this point lies at E in Fig. 25 then it can be said with 99 per cent. confidence that the value of $\bar{X}$ will not be less than the value shown.

If it is now decided that the limiting tolerable probability of failure is 1 in 1,000, the life of the component in service, N_s, must be such that

$$\log N_s < \bar{X} - 3{\cdot}09\,\sigma = \bar{X} - 0{\cdot}309,$$

point F in Fig. 25.

Hence

$$\log N_T = \log N_s + 0{\cdot}2326 + 0{\cdot}309$$
$$= \log N_s + \log 3{\cdot}48, \quad \text{or} \quad N_s = 0{\cdot}287\,N_T.$$

If, however, the value of N_T has been obtained from several, say 16 results, then although the value of σ is 0·1, when the mean of q tests is used as one test point σ is reduced to $\frac{\sigma}{\sqrt{q}}$, as indicated previously. Thus there are now two frequency curves each with a mean value of $\bar{X}$, but for the component $\sigma = 0{\cdot}1$, while for the test point which is the mean of 16 results, $\sigma = \frac{0{\cdot}1}{\sqrt{16}} = 0{\cdot}025$ (see Fig. 26). The value of N_s is now altered:

$$\log N_T = \bar{X} + \frac{2{\cdot}326 \times 0{\cdot}1}{\sqrt{16}} = \bar{X} + 0{\cdot}05815$$

with 99 per cent. confidence, while as before, $\log N_s = \bar{X} - 0{\cdot}309$ and, hence, $\log N_s = \log N_T - 0{\cdot}3672$, or $N_s = 0{\cdot}428\,N_T$.

Thus by using 16 specimens to obtain 16 experimental lives, the design life, with the same degree of confidence, has been increased by approximately 50 per cent. The weakness of this method is that the standard deviation of the distribution curve applicable to the component has to be assumed. Atkinson[13] has, however, used it to deduce design factors for certain conditions.

An alternative method has been suggested by Kennedy[12], which does not suffer from the difficulty of having to choose a value of σ; it is, therefore, of great value when no records of the testing of similar types of components are available, since the values of s and $\bar{x}$ calculated from the few results obtained are used. The two sources of error, i.e., $\bar{x} \neq \bar{X}$ and $s \neq \sigma$, can be allowed for with varying degrees of confidence. This is shown in Fig. 27. If A represents the value of x where probability of failure is 0·001 based on the distribution curve obtained from $\bar{x}$ and s, then the actual likelihood of failure may be much greater (the increase in probability is represented by the shaded area in Fig. 27). In this figure the true curve has been drawn to the left of the experimentally deduced curve so that the assumed probability of failure as given by A is low. It is equally likely of course that the true curve will be to the right of the experimentally deduced curve so that the assumed probability of failure as given by A will be high. The chances of the probability specified by A being high or low are 50 : 50, which means that the assumed probability of failure can only be relied upon to be equal to or less than the true probability with 50 per cent. confidence. If now the design level is moved from A to C the confidence has clearly increased. Lines CD, EF represent diagrammatically the 60 per cent. and 70 per cent. levels of confidence. Therefore, instead of using $\bar{x} - \lambda_p s$ where λ_p is the standard normal deviate associated with a probability of failure P, Kennedy has used $\bar{x} - Ks$ where it can be said that $\bar{x} - Ks < \bar{X} - \lambda_p \sigma$ with a certain degree of confidence. If the degree of confidence is specified by the standard normal deviate λ_c, then it can be shown that:

$$K = \frac{\lambda_p + \lambda_c \sqrt{\frac{1}{m}\left(1 - \frac{\lambda_c^2}{2\,(m-1)}\right) + \frac{\lambda_p^2}{2\,(m-1)}}}{1 - \frac{\lambda_c^2}{2\,(m-1)}} \qquad . \quad . \quad . \quad (5)$$

where m is the number of test results available.

Some values of K for $\lambda_c = 1{\cdot}6449$, i.e., 95 per cent. confidence, are given in Table IX, for various values

TABLE IX.—*Computed Values of K when* $\lambda_c = 1{\cdot}6449$, *i.e., 95 per cent. confidence*

m \ λ_p	1·282	2·326	2·878	3·090	3·291	3·721
3	8·748	13·335	16·402	17·584	18·706	21·104
4	4·257	7·291	8·934	9·568	10·170	11·460
5	3·382	5·750	7·035	7·532	8·004	9·014
6	2·964	5·025	6·144	6·576	6·987	7·867
7	2·712	4·595	5·617	6·012	6·387	7·191
8	2·542	4·307	5·265	5·635	5·986	6·739
9	2·417	4·098	5·010	5·363	5·697	6·414
10	2·322	3·940	4·817	5·156	5·478	6·167
20	1·911	3·274	4·009	4·293	4·563	5·140

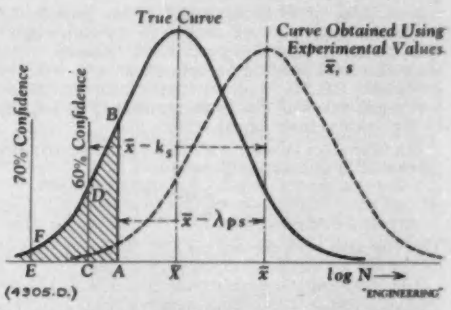


Fig. 27 Representation of the possible discrepancy between the true frequency distribution curve and a curve based on a small number of experimental values from which the mean value and the deviate are determined.

of λ_p and m. It will be seen, however, that equation (5) does not hold for $m = 1$, while for small values of m, k gets extremely large, which tends to make deductions with regard to design life very pessimistic.

WEIBULL'S METHOD

In the previous sections the methods which have been outlined for obtaining safe lives based on given probabilities of failure have dealt with the cases: (1) where a large number of components have been tested and $\bar{X}$, σ are fairly accurately known, and (2) where only a few results are available and either σ is assumed or s is used. These methods are all based upon the Gaussian distribution function. A different approach to the problem has been developed by Weibull.[14] Breaking away completely from the traditional normal distribution he has introduced his own distribution function and methods. These are particularly convenient for plotting P-S-N curves and the case P = 0 (i.e., no chance of failure) may be obtained easily. It is not proposed here to review his methods completely but some illustrations will be given. Weibull supposes that at one stress level S, the lives of m specimens in order of magnitude are $N_1, N_2, \ldots N_r \ldots N_m$ reversals. He then defines the expected probability of a specimen not surviving N_r reversals as P_r and deduces that P_r is approximately equal to $\frac{r}{m+1}$, which is independent of N_r.

These respective probability of failure values $\frac{r}{m+1}$ are now plotted against the values of x_r ($= \log N_r$) obtained, and the best smooth curve is drawn through or near these points. In Fig. 28 the values of x_r taken from Table VI are plotted against the values $\frac{r}{m+1} = \frac{r}{101}$. A smooth curve ABC has been drawn through these points. The corrected value

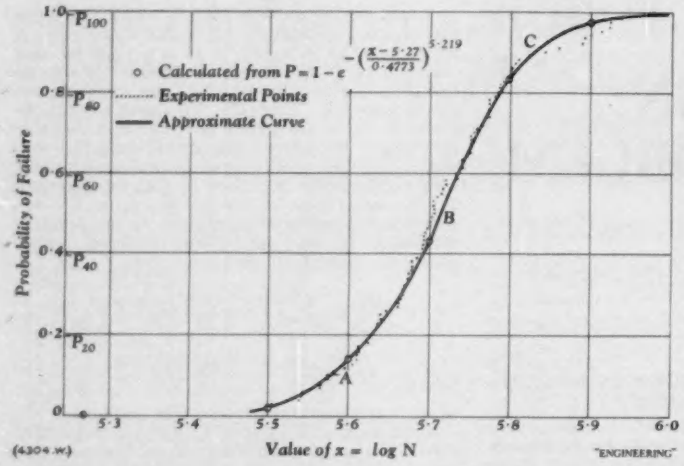


Fig. 28 (left) Probability of failure according to arguments proposed by Weibull. The curve is easily traced from experimental data and the parameters in the characteristic equation are evaluated from a sufficient number of discrete points, three, on the curve.

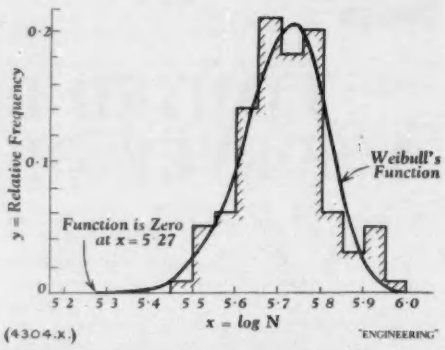


Fig. 29 (right) Comparison of Weibull's function with the data of Table VI drawn as a histogram.

of the probability of failure at a given life may be read from this graph. It is difficult to extrapolate the curve with any confidence and Weibull suggests that the function may be taken as

$$P(x) = \left[1 - e^{-\left(\frac{x-x_u}{x_0}\right)^W}\right]. \quad . \quad (6)$$

where $x = \log N$ and the three parameters x_0, x_u and W are to be determined.

Weibull suggests that if log N is now plotted against $\left[\log \frac{1}{1-P}\right]^{\frac{1}{W}}$, this should give a straight line if the correct value of W is assumed. It has been found by the authors, however, that large variations in W only cause a slight deflection from linearity. The alternative is to read the values of x at three levels of probability (10, 50, 90 per cent., say) from the smooth curve and calculate the three parameters W, x_0, x_u by elimination from equation (6).

For the values taken from Table VI, the probability calculated in this way is given by:

$$P(x) = 1 - e^{-\left\{\frac{x-5\cdot27}{0\cdot4773}\right\}^{5\cdot219}} \quad . \quad . \quad (7)$$

This has also been plotted on Fig. 28 and is seen to follow the approximate curve very closely.

The corresponding distribution curve has been plotted together with the histogram in Fig. 29. It is seen that in general a good fit is obtained, while the value of x at which there is no probability of failure is 5·27, or $N_{(P=0)}$ is $1{\cdot}8 \times 10^5$ reversals. $N_{(P=0{\cdot}5)}$ is $5{\cdot}1 \times 10^5$ reversals, which gives a ratio for $N_{(P=0{\cdot}5)} : N_{(P=0)}$ of 2·8 : 1.

Weibull does not attempt to justify his choice of $P(x)$ in equation (6) on mathematical grounds but maintains that since it has three parameters x_u, x_0 and W, a better fit to experimental data can be obtained than by using a normal distribution which has only two parameters $\bar{X}$ and σ.

This, briefly, seems an extremely simple method but it is necessary to realise its limitations. The true values of P_r, for instance, are not necessarily equal to $\frac{r}{m+1}$, and the degree of confidence which can be placed in the results cannot immediately be assessed from the smooth curve through the points $\left(\frac{r}{m+1}, N_r\right)$ plotted in Fig. 28. In general the true values of P_r lie about the value of $\frac{r}{m+1}$ and Weibull has given a distribution function

$$F_{\frac{r}{m}} = \frac{m!}{(r-1)!\,(m-r)!}\int_0^P t^{r-1}(1-t)^{m-r}\,dt$$

which gives the probability of P_r lying between 0 and P. In Fig. 30 three curves of $F_{\frac{r}{m}}$ are shown (after Weibull[16]). In each case the value of $\frac{r}{m+1}$ is 0·1 and the greater the number of results (i.e., the greater the value of m), the nearer is the distribution function to the line P = 0·1. If it is required that the probability chosen is to be less or equal to the true value P_r with, say, 90 per cent. confidence then the value of P (say $P_{r'}$) for which $F_{\frac{r}{m}} = 0{\cdot}9$ should be used. The curve in Fig. 28 can then be re-drawn by plotting log N_r against $P_{r'}$ values and this must be used for design calculations. The labour involved in the computation of $P_{r'}$ values (particularly when m is large) is considerable, but a few values have been obtained or $r = 1$ to 5 taking $m = 100$ and are given in Table X with the values of $\frac{r}{m+1}$. It is seen that as r increases $P_{r'}$ approaches the value $\frac{r}{m+1}$. Providing, however, this lack of confidence, as outlined in the last paragraph, is acceptable, this method is very amenable to the plotting of P-S-N curves.

TABLE X.—*Values of $P_{r'}$ for Different Values of m*

	r = 1	2	2	4	5
$\frac{r}{m+1}$	0·0099	0·0198	0·0297	0·0396	0·0495
$P_{r'}$	0·023	0·038	0·052	0·0685	0·078

APPLICATION TO COMPLEX STRUCTURES

When the probabilities of failure of several components are known it is instructive to deduce the probability of failure of a complex structure composed of such components. Suppose a structure made up from several parts is subjected to a number of stress reversals N, and the probability of failure of each part is P_1, P_2, . . . It is false to suppose that the probability of failure of the structure is equal to the probability of failure of the weakest part (i.e. the component most likely to fail). If the failure of any one component will cause failure of the structure as a whole then the structure can be likened to a chain with each separate link representing a component part. If after any given number of reversals N the probabilities that each link will fail are P_1, P_2, P_3, . . . P_r, what is the probability that at least one will fail? For each link the probability that it will not fail is given by $(1 - P_1)$, $(1 - P_2)$, . . . $(1 - P_r)$ and hence the probability that at least one failure will occur is $1 - (1 - P_1), (1 - P_2) \ldots (1 - P_r)$.

In Figs. 31 and 32 the probability of failure of each of several chains is compared with the probabilities of failure of the links comprising them. In Fig. 31 the probabilities of failure of three links, each of which is a member of one of three normally distributed populations with equal means ($\bar{X}_1$) but different variances (σ_1^2, σ_2^2, σ_3^2), are shown by straight lines OA, OB, OC. The curve DE, represents the probability of failure of a chain composed of three links, one from each population. In Fig. 32 a similar family of curves is shown for three links chosen from populations having three different means but the same variances. It is seen that for any given number of stresss cycles the probability of failure of the chain as a whole is greater than the probability of failure of any one link; and therefore on a basis of probability the chain is weaker than its weakest link !

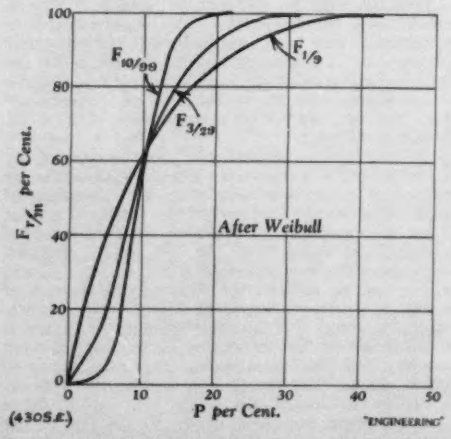


Fig. 30 Distribution functions showing the chance that the probability deduced by Weibull's method lies within 10 per cent. of the true probability. The chance improves as the number of specimens considered increases.

In Fig. 33 (after Tucker[16]) characteristics of chains of different length but made from links all drawn from the same population are shown. As was shown by the non-linearity of the probability curves in Figs. 31 and 32, the frequency distribution curves for the chains are skew even though that for the links is symmetrical. Both $\bar{X}$ and σ are functions of the number of links and these functions are shown in Fig. 34. In Table XI (taken from Tippett[17]) the value of $\bar{X}$ and σ for chains of, a, links are tabulated in terms of the mean value $\bar{X}_1$ and the standard deviation σ_1 of the single link population.

TABLE XI

Number of Links, a	Mean Strength of Chain, $\bar{X}_a$	Standard Deviation of Strength of Chain, σ_a
1	$\bar{X}_1$	σ_1
2	$\bar{X}_1 - 0{\cdot}56\,\sigma_1$	$0{\cdot}83\,\sigma_1$
10	$\bar{X}_1 - 1{\cdot}54\,\sigma_1$	$0{\cdot}59\,\sigma_1$
100	$\bar{X}_1 - 2{\cdot}51\,\sigma_1$	$0{\cdot}43\,\sigma_1$
10^3	$\bar{X}_1 - 3{\cdot}24\,\sigma_1$	$0{\cdot}35\,\sigma_1$
10^4	$\bar{X}_1 - 4{\cdot}38\,\sigma_1$	$0{\cdot}27\,\sigma_1$

It is clear from Fig. 34 (after Tucker [16]) that σ_a reduces consistently and at an ever decreasing rate. Consequently it may well be possible to make some deductions about the variance to be attached to extremely complex structures by testing smaller subassemblies of a less complex nature. This could be of great value in the assumption of standard deviates for use with a very small number of test results.

Research is urgently needed to find the range of values which may be anticipated for the statistical parameters for various complex engineering components at various values of mean life. Without this information it will be impossible to place on a sound scientific basis any statistical principle for designing from prototype test results.

DESIGNING TO FAIL SAFE

If care is not taken the statistical approach to design may lull designers into a false sense of confidence. A probability of failure of 1 in 100,000 may sound statistically quite satisfactory, but it all depends upon what is meant by failure. If the failure occurs in a minor component which prevents the machine from functioning properly, but does not endanger the whole machine or human life, then the probability approach to design is perfectly justifiable. If, however, a major component is involved the failure of which would endanger the whole machine and human life, then unless the probability on which the design is based is very small, the simple statistical approach is open to question. Furthermore, if a limited life design is based on a probability of failure of 1 in 100,000 then the machine must be taken out of commission after its design life, at which time 99,999 machines in 100,000 will still have some useful life left; some of them perhaps may run seven or eight times as long again. This may represent much useful life wasted.

The posing of this problem has produced a new philosophy in design which is being known as designing to " fail safe." It is too early yet to decide whether it is a sound philosophy for design or just a " heap of sand " in which the designer may put his head. It does, however, deserve serious attention as it appears to be the only possible method by which the statistical methods of design may be brought into

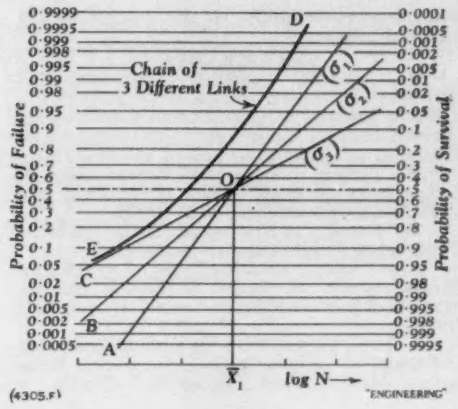


Fig. 31

Figs. 31 and 32 The probability of failure of a complex structure composed of several components is not equal to probability of failure of the weakest component. The graphs illustrate this for a chain composed of three links. In Fig. 31 each link is of materials for which the mean strength is the same, but for which deviation coefficients differ; in Fig. 32 the materials of the links have different mean strengths though the coefficients are equal.

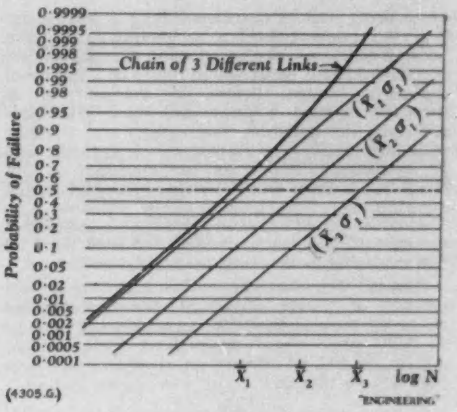


Fig. 32

line with the moral obligations of the engineer to the community.

What is meant by fail safe? If the design life of an aeroplane is 100,000 hours say, and the wing construction embodies a single main spar, should that spar fail in less than the specified life, then it is most likely that the wing would completely collapse and a serious accident would result. If, however, the wing had four main spars and one failed before 100,000 hours then the load on the remaining three would be increased greatly which would shorten their life, but they would last a sufficient length of time to enable the pilot to make an emergency landing at the nearest airport. This obviously may reverse certain design trends and might add to the weight of the structure if the same working stresses were used. But on the fail safe principle much added confidence is obtained and the net result might well be that higher working stresses could be used and still achieve a higher confidence in design; the result being an all-round improvement. This, however, is another problem urgently needing investigation both from a statistical point of view and experiments with actual design.

So far we have considered the implementation of the principle of fail safe by converting a single component design into a multi-component one. There are, however, certain components such as rotor discs which are essentially single components, yet under certain conditions the failure of these discs can be disastrous. How can fail safe be applied to such components? We are considering not simply the rotational bursting stresses which, within our definition, would be classed as static design stresses, but the effects of starting, stopping and vibration stresses superimposed on these static stresses. What must be prevented is complete bursting of the disc. If distortion occurs in the rotor disc, then the blades would be displaced radially outwards and would catch on the stator casing. This would not generally produce catastrophic failure but the condition would be apparent and the turbine could be shut down. The solution, then, seems to be to persuade the fatigue crack after its first initiation to follow a path which would allow a small portion of the disc to be displaced outwards and so give warning of failure as outlined above.

A most hopeful line of approach to this problem is to design crack barriers in the disc, so that when a crack starts on the periphery after propagating radially inwards for a short distance it is compelled to propagate in a circumferential direction. If this happens before the crack has propagated radially very far, the centrifugal forces will be sufficient to force a piece of the periphery to distort sufficiently to give warning and so avoid catastrophic failure.

Here again, problems for research are thrown into relief. Firstly much more must be known of the basic mechanism by which cracks propagate, and secondly the development of suitable crack barriers must be investigated.

CONCLUSIONS

The change of design philosophy which has been outlined has been gradual and natural like any other evolutionary process. What, however, is not always appreciated is that a new philosophy of design may require new information and if the change has been basic then engineering tradition will be a poor and unsatisfactory substitute for real information and knowledge. The authors feel that as far as limited life design is concerned the time has arrived when it is essential that an objective assessment of the problem should be made to see where our knowledge is least and, therefore, in which directions the spearhead of research should be directed. The various aspects of the problem have been dealt with in an elementary manner, this being considered the best method of presenting the difficulties and exploring the gaps in our knowledge. One of the main objects of this paper has been to reveal those aspects of the problem of limited life design where our knowledge is weakest and where further research seems desirable.

Each aspect of the problem which demands further attention is discussed below.

Load Spectra.—The first fact that becomes apparent in this survey is that whereas in static design one requires only the maximum load on the component, in dynamic design a knowledge of the whole load spectrum is necessary. When preparing this paper efforts were made to obtain typical load spectra for various engineering components. Apart from the aircraft industry such information seems to be non-existent. The collecting and recording of load spectra is most important and should be done wherever possible.

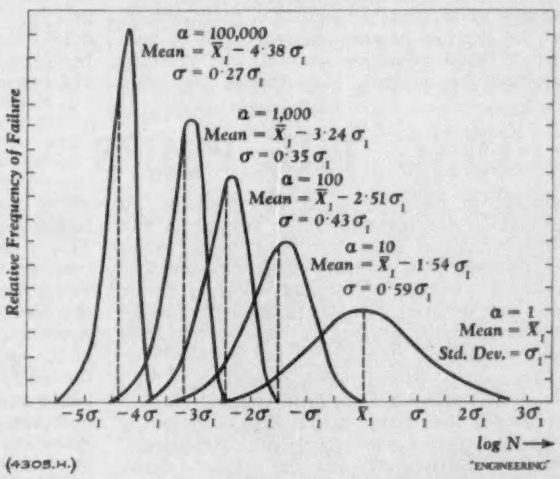


Fig. 33 (above) Probability characteristics of chains composed of different numbers of similar links.

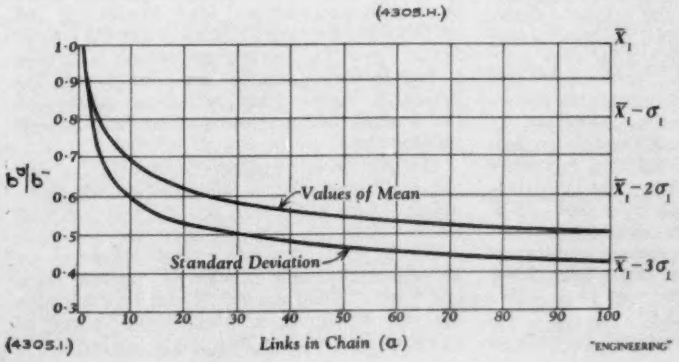


Fig. 34 (left) Frequency curves of probable failure for chains containing different numbers of links.

Cumulative Damage.—There is no real understanding of cumulative damage in fatigue and the suggested modified Miner's Law $\Sigma \frac{n}{N} = 0{\cdot}6$ is presented as a safe but empirical law. Further progress is dependent upon a larger research effort: (*a*) Upon a fundamental understanding of the fatigue phenomenon. This would at least enable a beginning to be made towards understanding the mechanism of cumulative damage. (*b*) Tests on notched specimens under various load spectra and various patterns of means and oscillating stress are badly needed. (*c*) Tests similar to (*b*) on complex components and a limited amount of testing on complete structures, are required to see the extent to which the relationships applicable to notched specimens can be applied to actual components.

It may take many years, if it is not impossible, to obtain sufficient information to deduce a general and comprehensive law for cumulative damage but in the empirical law $\Sigma \frac{n}{N} = K$ an extension of our knowledge to fix K for various conditions of stressing and components would be a considerable advance.

Fatigue Strength.—On the metallurgical side efforts are needed to raise the fatigue strength of high static alloys, especially when stress raisers are present. Here again research into the fundamental nature of fatigue is a first essential.

Scatter in Life for Engineering Components and Structures.—In considering the application of statistical methods to design various methods have been discussed. It is not intended in this paper to assess the relative merits of these methods. Whichever one is used there is a great need for further knowledge of the scatter (or standard deviation) likely to appertain to various components. When making prototypes, obviously only very few will be available for testing and the value of these few test results is greatly enhanced if the degree of scatter normally encountered with such components is known. There must be many obsolete engineering components which, if proper facilities were available, could be tested, prior to scrapping, to provide such information. When more experimental data become available it might be found possible to divide engineering components into various categories and define the scatter anticipated in each.

Further, it is obviously going to be difficult and expensive to test a large number of complete structures and research is urgently needed to investigate how the probability of failure varies with the complexity of the structure. It may well be that very little error would be involved if the standard deviation calculated for a sub-assembly were used for the complete structure. If this is the case then ultimately a great deal of expense and time will be saved.

Percentage Confidence and Percentage Probability.—Most methods which calculate the life (or working load) for a component from a few tests on a prototype involve two factors: the specified probability of failure and the defined confidence demanded in the deductions from the test results. It is never possible to state a probability of failure with 100 per cent. confidence, even when this probability of failure is zero. There is at present no universally accepted degree of confidence which can be used in design. A lead for the designer is obviously required here. This aspect is also of importance when considering the size of any test programme.

"*Fail Safe*" (*Multi-Component Structure*).—When designing a multi-component structure for fail-safe, a new conception of design is presented which should be explored to the full. Not only theoretical investigations but confirmatory experimental tests should be carried out. Obviously when one prime component breaks the additional load on the remaining

components must be distributed more or less evenly. If this is not done, fail-safe is not likely to be achieved.

Crack Barriers.—The introduction of crack barriers as outlined in the paper will in future be a feature of engineering design. Before this method can be effectively applied a great deal more knowledge governing the initiation, propagation and arresting of fatigue cracks must be known. Due to the lack of fundamental knowledge the approach to this problem, for some years to come, must be basically experimental. Consideration of the variables to be contended with will give an idea of the magnitude of the research programme needed if it is to be at all effective as far as the designer is concerned.

General.—Anyone who makes a survey of the problem of limited life design must be concerned about the position in which the engineering designer of high performance components finds himself. As far as limited life design is concerned he is fumbling in the dark. His role is like that of a detective with so few clues that he is never sure whether he is progressing towards the solution or about to be the next victim. From the point of view of engineering science and the engineering industry, the position is serious and one needing urgent attention. It is well to ask whether it is sufficient to promote *ad hoc* research in various forms in an effort to solve the immediate problems and to encourage an isolated fundamental worker here and there to investigate that aspect of the problem which stirs his interest. The former must go on and the latter should be encouraged; but is that sufficient?

The programmes outlined in these conclusions would cost many millions of pounds to carry out, but, more important, they would also absorb a number of most able men. Knowing the shortage of applied scientists in this country, one may well ask whether the problem is of such importance as to justify this? It is neither possible nor proper for the authors to answer this question, but it is one to which responsible bodies in this country should address themselves.

BIBLIOGRAPHY

[12] R. J. Atkinson, "Permissible Design Values and Variability Test Factors." R. and M. No. 2877, (1955).

[13] A. P. Kennedy, "A Method for Determining the 'Safe' Life of an Aircraft Wing from Fatigue Test Results," *J. of the Royal Aero. Soc.*, vol. 58 (1954).

[14] W. Weibull, "A Statistical Representation of Fatigue Failure in Solids," *Trans. of the Royal Inst. of Technology*, Stockholm, No. 27 (1949).

[15] W. Weibull, "A New Method for the Statistical Treatment of Fatigue Data," SAAB TN. 30.

[16] John Tucker, "Statistical Theory of the Effect of Dimensions and of Method of Loading upon the Modulus of Rupture of Beams", *A.S.T.M.*, page 1072 (1941).

[17] L. H. C. Tippett, "On the Extreme Individuals and Range of Samples Taken from a Normal Population," *Biometrika*, vol. 17, page 364 (1925).

Book Reviews

THE TRUTH ABOUT BRUNEL

Isambard Kingdom Brunel: A Biography. By L. T. C. Rolt. *Longmans, Green and Company, Limited, 6 and 7 Clifford-street, London, W.*1. (25*s.*)

Outstanding among the great engineers responsible for the quickening tempo of the industrial revolution in the first half of the Nineteenth Century was Isambard Kingdom Brunel. Yet it is true to say that his accomplishments are but dimly understood by the majority of people. He is known, perhaps, as the creator of the Great Western Railway, and his name is inseparably connected with the last of his many achievements—for such it was, in spite of being a commercial failure—the "Great Eastern" steamship.

Regrettable though it is, ignorance of the part played in the history of the world by such men as Brunel is understandable, because they have been so inadequately served by the literary world in the past. Politicians, soldiers, social reformers, philosophers, divines, noblemen, artists, have all found their biographers; yet as Mr. Rolt says, all these people were ". . . so many puppets jerked by the steel threads spun by the engineers and dancing to the tunes they called." This studious ignoring of engineers in the past is capable of one simple explanation, which is exemplified by Mr. Rolt's book. Writers in the past took no account of the engineers simply because they did not understand engineering. The technicalities involved were beyond them, and what they failed to comprehend they chose to ignore.

Mr. Rolt studied engineering, and he sees Brunel through an engineer's eyes. Consequently he is able to weigh the evidence fairly, and to discard or put into true perspective the records of those who had no understanding of the technicalities involved. From such an appraisal of the facts (including many not hitherto available to research workers), there has emerged a balanced, critical study of a most remarkable engineer. For the first time Brunel's achievements and failures—he was the first to admit that not all his schemes were successful—can be seen against a proper technical background. But this is no arid technical treatise of mere facts and figures. Engineers are also human beings, with their friends and enemies and their full share of hopes and fears, trials and triumphs; these human factors, too, are given proper consideration.

Brunel's career was not of the type which Samuel Smiles delighted to record. He had no early struggles against abject poverty and ignorance, and he was not a "Self Help" character who, by his own unaided effort and perseverance, passed through a life of achievements to a comfortable old age loaded with worldly goods and honours. On the contrary, he was born of parents who were able to give him a good education and all the creature comforts he needed. Nevertheless, his trials were many, and he often found it necessary to call on his great reserves of energy. Far from living to enjoy a comfortable retirement, he died at the age of 52, engaged in a bitter struggle against what must surely have seemed to him to be an unreasonable fate. Like all great men he had his enemies and his detractors, and it was the hostility of some and the unco-operative nature of others that caused so much of the ill-feeling and distrust which characterised the protracted building of the "Great Eastern." That Brunel had a great deal of trouble with this, for its time, monster ship, is well known; why that trouble occurred has always been more obscure. Mr. Rolt has brought to light many hitherto unknown facts and illuminated many dark corners in the sometimes sordid story of the great adventure. His researches sought only the truth; in finding it he has established Brunel's reputation more firmly than ever.

The book serves a threefold purpose. It is a model of how the life of an engineer should be studied, from an engineering point of view; it is a well-told, even thrilling, story which can be read with great pleasure and profit; and it is an excellent reference book, for which purpose a good index has not been forgotten. It ought always to have been obvious that a book dealing with engineering history should be written by someone who combined technical knowledge with the ability to write. Some of the books which have appeared with depressing regularity over the years have failed to recognise this elementary principle. Mr. Rolt has shown what can be done when the two requisites are met. It is to be hoped that his pen will not be idle for long, and that others will follow his example.

FEEDING THE PRESS

Industry and Press Relations. By Peter Hayle. *Staples Press Limited, Mandeville-place, London, W.*1. (12*s.* 6*d.*)

Until the war, British industrialists fought shy of the Press. Goods were sold without its help, and it was largely a nuisance. But the cost of advertising has so increased that businesses to-day are very reliant on the Press for "free" publicity. And because industry is now also so much more noticed by the general public, the need of a sound, workable public relations policy in every sort of industry cannot be over-rated. The author of this book—his pseudonym is said to conceal a well-known industrial journalist—suggests how modern Press policies can be formulated, and he makes numerous positive suggestions for putting these policies into being. Finally, he explains those major journalistic technicalities with which the present-day Press officer should be familiar.

In the United States, where almost every industrialist considers Press relations of vital importance, it has been estimated that "free" advertising in the form of Press publicity may be worth as much as eight times what the same amount of space would cost if bought for conventional advertising. It has also been noted in America that almost all Press publicity—even the negative sort—is in the end good for business. In Britain, where newspapers are smaller in size than American ones but have much larger circulations, Press publicity should be even more valuable. British industrialists, slow to realise this, have watched in dismay as aggressive foreign businesses have received a disproportionately high amount of publicity in the British Press.

Too often British industrialists view their Press officers as necessary evils, and as "Hayle" points out, their main function often seems merely to keep their employers' names out of the papers. Also, as he suggests, too many Press officers feel that they accomplish most by entertaining the Press lavishly. Presenting them with good stories would be more to the point. Just because publicity expenses are income-tax deductible, too many employers say, "Why not let the newspapermen have a good time?" Journalists, of course, may not resent this, but Press parties do not alone make copy, and journalists who do not get stories lose their jobs. Few British journalists are either so negative or so malicious that they will present an unpleasant story when given a pleasant one. Even fewer resent being told all the facts, even those which they are requested not to write.

If any criticism of this book can be made at all, it is that it does not present full enough instructions for dealing with the overseas Press. This is an aspect of public relations which has been almost entirely ignored by British industry. Few Press officers seem capable of dealing with the foreign Press, and particularly with the American Press. Curiously, this is most true of the majority of industries that try to sell on the highly competitive American market. Practically no British Press officers seem to realise that the differences between the English and American languages alone are sufficiently great to make it worth while at least considering the preparation of separate statements for the United States. And too many Press officers here take a high-handed, superior attitude toward the American Press. Their incredible excuse for this is that their employers never read foreign publications!

The author also neglects to explain the full value of the free-lance journalist to the Press officer. Such journalists, because they are paid usually only for those of their stories which appear in print, are worth a small fortune to the Press officer patient enough to cultivate them and "feed" them stories. The author has also omitted explaining a fundamental point of courtesy ignored by too many British Press

officers. Few of them ever take time to thank journalists for favourable stories. Among themselves, journalists comment on this.

If its writing were a little less arid, if more and livelier anecdotes were used to draw its points, this book would have the makings of a best-seller. As it is, it deserves a place on the desk of almost every industrial executive in the country. Few journalists would contradict any of its major points.

Editorial comment on this review appears in Plain Words, page 258.

★ ★ ★

NEW BOOKS

The British Shipbuilding Compendium, 1957. Seventh edition. *The Shipping World, Limited, Effingham House, Arundel-street, Strand, London, W.C.2.* (20*s.*)

As in the previous edition, this trade directory is divided into four main sections—shipbuilding, propulsion machinery, general and shipyard equipment. Each of these sections is subdivided into classified categories, and to facilitate the use of the book an alphabetical index of headings is provided. There is also an alphabetical index to firms.

Combustion Researches and Reviews, 1957. The Advisory Group for Aeronautical Research and Development, North Atlantic Treaty Organisation. *Interscience Publishers Inc., 250 Fifth-avenue, New York 1, N.Y., U.S.A.* (5.60 dols.); and *Butterworths Scientific Publications, 88 Kingsway, London, W.C.2.* (40*s.*)

Ten papers, presented to the AGARD Combustion and Propulsion Panel, concerning pulse jets, shock-tube techniques and high-pressure combustion, are reproduced in this volume. Four of the papers (one in French) deal with flames; two are theoretical combustion analyses; two, both in French, are concerned with pulse jets, and two deal with the determination of physico-chemical and thermodynamic data required in combustion research.

Refrigeration and Air Conditioning. By R. C. JORDAN and G. B. PRIESTER. *Constable and Company, Limited, 10 Orange-street, London, W.C.2.* (65*s.*)

First published in 1948, this book is intended to provide a comprehensive course in refrigeration and air conditioning for senior and graduate students, and to serve as a reference work for practising engineers. It can also be adapted to serve the needs of more elementary courses. In the first part of the book, the history of refrigeration is surveyed, basic refrigeration cycles and concepts are discussed and thermodynamic relationships are reviewed. There follow sections dealing with refrigeration cycle analysis and compression-refrigeration machines; fluid flow and heat transfer; advanced topics such as multiple systems, refrigeration control, absorption refrigeration and chemical dehumidification; and refrigeration applications, including air conditioning and food processing. Throughout the work, theory, application and equipment are integrated. Bibliographies are provided at the end of each chapter, and an extensive set of graded problems. The index appears to be comprehensive.

★ ★ ★

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Liquid Flow, Level and Pressure Measuring Instruments. ETS NEYRPIC, 155 Boulevard Haussmann, Paris. Current meters and midget current meters for scale models; pitot tubes, traversing and non-traversing; weirs; luminous floats; courantographe for recording direction and intensity of currents; recorder for bed and surface studies in scale models; limnigraphs for recording water-level; houlographe for measuring pressures in waves; wave recorders; conductivity meters; sampling devices; pressure recorders. Illustrated brochure with specification data.

P.V.C. Ducting. HORWITCH SMITH AND CO. LTD., 42 Lower Loveday-street, Birmingham, 19. Oxythene Duoply laminated P.V.C. ducting, plain exhaust ducting, 45 deg. and 90 deg. bends, T-pieces, deflector caps, weather pieces, square-to-round transformer pieces, in internal diameters from 4 in. to 20 in. Illustrated specification leaflet.

High Vacuum Pumps. EDWARDS HIGH VACUUM LTD., Manor Royal, Crawley, Sussex. Speedivac rotary high-vacuum pumps and accessories, from miniature laboratory pumps to high-capacity industrial units. Illustrated brochure with specification data.

Dust Collection. VISCO ENGINEERING CO., LTD., Stafford-road, Croydon. "Modern Dust Collection"—principles of dust collection and detailed description of dust-collecting plants. Illustrated brochure.

Cold Galvanising. EXPANDITE LTD., Chase-road, London, N.W.10. "Metagalv" galvanising paint for brush application. Dries in 30 minutes. Leaflets.

Packaged Boilers. G.W.B. FURNACES, LTD., Dibdale Works, Dudley, Worcs. Examples of recent installations of "Powermaster" packaged boilers, and list of sizes and ratings. Leaflet.

On the Shelf

By Frank H. Smith

The National Book League issues reader's guides to various branches of literature and while 12 of the 13 titles have no connection with engineering, number 9, which has been published recently, deals with, and is called, *The History of Flying*. The compiler, C. H. Gibbs-Smith, has already written a well-known book of the same title (if the indefinite is substituted for the definite article) and will be recognised by some as a writer of material on balloons and as a broadcaster of repute. The guide's price is 3*s.*, and the address of the League is 7 Albemarle-street, London, W.1.

Zentralstelle der Luftfahrtdokumentation (ZLD) of München 64, Flughafen, have issued an index of early German research publications that are available in microfilm or photocopy form. Documents are in alphabetical order of author, followed by title and by such code letters as FB, TB, LG, and the reference number. While these letters mean nothing to the "ordinary" documentalist they have some significance for the aeronautical type for whom, of course, the index is intended. Multi-coloured pages, at the end of the book, index such items as Jahrbücher der deutschen Luftfahrtforschung, the Ringbuch and die deutsche Akademie der Luftfahrtforschung. I am afraid I cannot quote a price for this index.

Sheffield Interchange Organisation (SINTO—Ugh!) have sent me their duplicated *Review of Progress* 1956-7. As is the case with most organisations connected with books, their figures show an increase over the previous year. It is evident from the tone of the report that, in the Sheffield district, there is a happy relationship of co-operation between the public library service and the local industry and research libraries. This even extends to interchange of staff, which is a most valuable arrangement for specialised librarians wishing to take the Library Association examinations. Too often technical librarians can only acquire the knowledge necessary for the L.A. examinations by sheer hard study from books, which is a poor substitute for practical experience.

The report emphasises the value of personal relationships and contacts within SINTO. This personal business cannot be emphasised too often. In a profession devoted to getting information to the client, knowing where to get it and having the goodwill to get it—and quickly—is of greater value than all your theory of decimals.

Number 1 of *LLU News* has appeared on my desk. It is not, as I at first thought, an obscure Welsh news-sheet but is a four-page pamphlet giving the first news of the requirements, aims, limits and other features of the National Lending Library for Science and Technology. This, by the way, is the title for the projected library which is to end all libraries. The information in the pamphlet is too lengthy to be abstracted here but a copy can probably be obtained from the Department of Scientific and Industrial Research, 20 Chester-terrace, London, N.W.1 (Telephone: HUNter 8361).

In 1955 the Institution of Naval Architects published *The Papers of William Froude*. As a result of this, two further papers have come to light and the Institution has reprinted them and rather ingeniously given the addendum a gummed edge so that it can be fixed into the back cover of the original volume.

On page 799 of our issue of June 21, reference was made to a debate in the House of Commons on scientific information and, *inter alia*, Mr. A. Skeffington's remarks on the need for adequate indexing were quoted. As a result of this, a copy has been received of *Garraway's Electrical Register*, which is "a weekly record of electrical-engineering progress incorporating a weekly cumulative index." It is published by Garraway Limited, 11 Kensington Church-street, London, W.8. I suspect that persons interested in the subject know of this abstract service but, in case they do not, the subscription is £10 per annum. The circulation manager is to be congratulated on a fine sense of opportunism.

In Britain, in the U.S.A., and probably in other countries, there are mobile libraries serving outlying districts by motor van. Sweden is probably alone in running library trains. The *Information Bulletin* of the Centre d'Information des Chemins de Fer Européens (No. 4, Vol. 7) describes how these trains have been running for some time on the so-called mineral lines. Here there is a very sparse population whose only communication with the outside world is the railway line.

Persons who know that classic booklet *The Specialist* and/or John Pudney's book *The Smallest Room*, may wish to extend their knowledge; in which case I would bring to their notice G. L. Ackers's paper in the *Journal of the Royal Society of Arts*, No. 5009, entitled "Plumbing." This rather prosaic title gives no indication of the interest in the paper, which should appeal not only to the engineer and designer but also to the householder. Do you, know, for example, why it is an unwise policy to put the mirrors over the wash-basins in ladies' wash-rooms?

Soviet News reports the visit of a delegation of American peat experts to the Soviet Union. For peat's sake!

The Aluminium Development Association, 33 Grosvenor-street, London, W.1, has issued another of its useful little information bulletins. The title is *The Brazing of Aluminium and its Alloys*, the price is two shillings and it is No. 22 in the series. At this price it is not, of course, intended to be an exhaustive treatise but is rather an indication of applicability. An eight-item bibliography gives titles of other publications for further study.

Operation research is a science that developed greatly during the last war. Since the war it has been applied to many branches of science and industry and it may not be generally known that there is an Operational Research Society, which publishes the *Operational Research Quarterly*. Three titles taken from the latest issue, that for June, give some indication of the range of this branch of science. They are: "Management in Action," "The Effectiveness of Present-day Crash Helmets for Motor-cyclists" and "The Consequences of Economic Stabilisation." Further information may be obtained from the Society's honorary secretary, Mr. B. H. P. Rivett, 2 Grosvenor-place, London, S.W.1.

Research and Development

REINFORCED HOLES IN PLATES

TOTAL WEIGHT REDUCED BY VARYING THICKNESS OF REINFORCEMENT

By Raymond Hicks, PH.D., M.SC.*

Summary.—*The presence of a uniform reinforcement around a circular hole in a plate loaded in its own plane results in a decrease of the stress concentration. In a previous article† it was shown that when the weight of the structure (that is, plate plus reinforcement) is constant, this stress concentration can be further reduced by suitably varying the cross-sectional area of the reinforcement. Thus, when the maximum stress is nowhere to exceed a given value, the effect of varying the cross-sectional area of the reinforcement is to decrease the necessary weight of the structure.*

In this discussion expressions are obtained for the radial, tangential and shear stress components in an infinite plate under the action of (a) *constant shear stresses, and* (b) *unequal principal stresses. These expressions are written in terms of a set of arbitrary constants which can be evaluated for any particular numerical example.*

THEORY

For an infinite plate uniformly stressed in one direction, the radial, tangential and shear stress components are given by

$$\widehat{rr} = \frac{a_0}{r^2} + \frac{f}{2} - \sum_2^\infty \left[\frac{a_n}{r^n}\left\{\frac{n(n+1)}{r^2} - \frac{(n-1)(n+2)}{b^2}\right\} + f\,\delta_2\left\{\frac{b^2}{r^2} - \tfrac{1}{2}\right\}\right]\cos n\theta. \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$\widehat{\theta\theta} = -\frac{a_0}{r^2} + \frac{f}{2} + \sum_2^\infty \left[\frac{a_n}{r^n}\left\{\frac{n(n+1)}{r^2} - \frac{(n-1)(n-2)}{b^2}\right\} - \frac{\delta_2 f}{2}\right]\cos n\theta. \quad (2)$$

$$\widehat{r\theta} = -\sum_2^\infty \left[\frac{n\,a_n}{r^n}\left\{\frac{(n+1)}{r^2} - \frac{(n-1)}{b^2}\right\} + \frac{f\,\delta_2}{2}\left\{1 + \frac{b^2}{r^2}\right\}\right]\sin n\theta. \quad (3)$$

where $\delta_2 = 1$ when $n = 2$ and $\delta_2 = 0$ when $n \neq 2$, f is the applied stress acting in a direction parallel to the radial line $\theta = 0$, and a_n a constant chosen to satisfy the compatibility condition.

$$(\widehat{\theta\theta} - \nu\,\widehat{rr})_b \frac{A_R}{bh} - (\widehat{rr})_b = 0. \quad . \quad (4)$$

where $2b$ is the diameter of the hole, h the thickness of the plate, A_R the cross-sectional area of the reinforcement, and ν Poisson's ratio.

Using the principle of superposition and rotating the co-ordinate axes through 45 deg., the above expressions for the stress components in a plate uniformly stressed in one direction can be used to obtain the following expressions for the stress components in an infinite plate under the action of a constant shear stress distribution.

Thus if q is the applied shear stress

$$\widehat{rr} = -\sum_2^\infty \left[\frac{a_n}{r^n b^2}\left\{n(n+1)\frac{b^2}{r^2} - (n-1)(n+2)\right\} + q\left\{\frac{2b^2}{r^2} - 1\right\}\delta_2\right]\sin n\theta. \quad . \quad . \quad . \quad (5)$$

$$\widehat{\theta\theta} = \sum_2^\infty \left[\frac{a_n}{r^n b^2}\left\{n(n+1)\frac{b^2}{r^2} - (n-1)(n-2)\right\} - q\,\delta_2\right]\sin n\theta. \quad (6)$$

$$\widehat{r\theta} = \sum_2^\infty n\left[\frac{a_n}{r^n b^n}\left\{(n+1)\frac{b^2}{r^2} - (n-1)\right\} + \frac{q}{2}\left(1 + \frac{b^2}{r^2}\right)\delta_2\right]\cos n\theta. \quad (7)$$

The stresses around an un-reinforced hole in a similarly loaded plate are

$$(\widehat{rr})_b = (\widehat{r\theta})_b = 0. \quad . \quad . \quad . \quad (8)$$

$$(\widehat{\theta\theta})_b = -4q\sin 2\theta. \quad . \quad (9)$$

Thus the stress concentrations occur on radial lines which bisect the co-ordinate axes. It therefore follows that a suitable reinforcement would have a variable cross-sectional area given by the expression

$$A_R = \alpha' + \beta'\cos 4\theta. \quad . \quad (10)$$

where α' and β' are constants which are chosen so that $\alpha' + \beta'$ is the area of the reinforcement when $\theta = 0$, and $\alpha' - \beta'$ is the area when $\theta = \frac{\pi}{4}$.

From (4) and (10) the compatibility condition becomes

$$(\widehat{\theta\theta} - \nu\,\widehat{rr})_b(\alpha + \beta\cos 4\theta) - (\widehat{rr})_b = 0. \quad (11)$$

where $\alpha = \dfrac{\alpha'}{bh}$ and $\beta = \dfrac{\beta'}{bh}$.

Substituting in (11) the appropriate expressions for the stress components and writing

$$2\cos 4\theta\sin n\theta = \sin(n+4)\theta + \sin(n-4)\theta$$

the compatibility condition becomes

$$\sum_2^\infty \left\{q[1-(1-\nu)\alpha]\,\delta_2 + \frac{2a_n}{b^{n+2}} \times [(2n-1+\nu)\alpha + 1]\right\}\sin n\theta + \sum_2^\infty \frac{\beta}{2}\left\{-q(1-\nu)\,\delta_2 + 2(2n-1+\nu)\frac{a_n}{b^{n+2}}\right\} \times \{\sin(n+4)\theta + \sin(n-4)\theta\} = 0. \quad (12)$$

To satisfy this condition at all points around the hole, the coefficient of each $\sin n\theta$ term (n even) must be zero, so that

$$\sum_0^\infty \left\{q[1-(1-\nu)\alpha]\,\delta_2 + \frac{\beta}{2}q(1-\nu)\,\delta_2 - \frac{\beta}{2}q(1-\nu)\,\delta_6 - \frac{\beta a_2}{b^4}(3+\nu)\,\delta_2 + \frac{2a_n}{b^{n+2}}[(2n-1+\nu)\alpha + 1] + \frac{\beta a_{n-4}}{b^{n-2}}(2n-9+\nu) + \frac{\beta a_{n+4}}{b^{n+6}}(2n+7+\nu) = 0\right\}. \quad . \quad . \quad . \quad (13)$$

where

$\delta_2 = 1$ when $n = 2$ and $\delta_2 = 0$ when $n \neq 2$.

$\delta_6 = 1$ when $n = 6$ and $\delta_6 = 0$ when $n \neq 6$.

$a_0 = a_{-2} = 0$.

When dealing with any particular problem the solution of (13) gives values for the constants a_n which occur in the above expressions for the stress components. It is worth noting that since the stress distribution is symmetrical with respect to lines inclined at 45 deg. to the directions of the applied shear, the constants $a_4, a_8, a_{12} \ldots$ must be zero.

For a reinforcement having a constant cross-sectional area $\beta = 0$ the constants are given by

$$a_2 = -q\left[\frac{1 + \alpha\nu - \alpha}{3\alpha + \alpha\nu + 1}\right]\frac{b^4}{2}.$$

$a_n = 0$ when $n \neq 2$.

As a numerical example, let

Poisson's ratio = 0·3.
Diameter of hole = 5 in.
Thickness of plate = 0·04 in.
Width of reinforcement = 0·1 in.
Depth of reinforcement = 0·25 in. when $\theta = 0$.
Depth of reinforcement = 0·5 in. when $\theta = \frac{\pi}{4}$

For a plate and reinforcement having these dimensions, the first seven constants in the expressions for the stress components are

$$a_2 = -0{\cdot}1470\,q\,b^4$$
$$a_6 = -0{\cdot}00962\,q\,b^8$$
$$a_{10} = -0{\cdot}000842\,q\,b^{12}$$
$$a_{14} = -0{\cdot}0000988\,q\,b^{16}$$
$$a_4 = a_8 = a_{12} = 0.$$

Using these values for the constants it is found that the effect of reinforcing the hole is to decrease the maximum stress in the plate from $4q$ to $1{\cdot}6981\,q$.

Using the principle of superposition, it is found from (1), (2) and (3) that for a plate under the action of principal stresses f_x and f_y at infinity, the stress components are given by

$$\widehat{rr} = \frac{A}{r^2} + \left(\frac{f_x + f_y}{2}\right) - \sum_2^\infty \left[\frac{a_n}{r^n}\left\{\frac{n(n+1)}{r^2} - \frac{(n-1)(n+2)}{b^2}\right\} + (f_x - f_y)\left\{\frac{b^2}{r^2} - \tfrac{1}{2}\right\}\delta_2\right]\cos n\theta. \quad (14)$$

$$\widehat{\theta\theta} = -\frac{A}{r^2} + \left(\frac{f_x + f_y}{2}\right) + \sum_2^\infty \left[\frac{a_n}{r^n}\left\{\frac{n(n+1)}{r^2} - \frac{(n-1)(n-2)}{b^2}\right\} - \left(\frac{f_x - f_y}{2}\right)\delta_2\right]\cos n\theta. \quad . \quad . \quad (15)$$

$$\widehat{r\theta} = -\sum_2^\infty \left[\frac{n\,a_n}{r^n}\left\{\frac{(n+1)}{r^2} - \frac{(n-1)}{b^2}\right\} + \left(\frac{f_x - f_y}{2}\right)\left\{1 + \frac{b^2}{r^2}\right\}\delta_2\right]\sin n\theta. \quad (16)$$

The stresses around an unreinforced hole in a similarly loaded plate are

$$(\widehat{rr})_b = (\widehat{r\theta})_b = 0. \quad . \quad (17)$$

$$(\widehat{\theta\theta})_b = (f_x + f_y) - 2(f_x - f_y)\cos 2\theta. \quad (18)$$

A suitable reinforcement would therefore have a cross-sectional area given by the expression

$$A_R = \alpha' + \beta'\cos 2\theta. \quad . \quad (19)$$

Substituting (14), (15) and (19) in (4) and equating the coefficients of the $\cos n\theta$ terms to zero, it is found that

$$\sum_0^\infty \left\{N\,\delta_0 + M\,\delta_2 + \frac{2a_n}{b^{n+2}}[\alpha(2n-1+\nu)+1] + \beta\left[(2n-5+\nu)\frac{a_{n-2}}{b^n} - (1-\nu)(f_x - f_y)\frac{\delta_4}{4} + (2n+3+\nu)\frac{a_{n+2}}{b^{n+4}}\right] = 0\right\}. \quad . \quad . \quad (20)$$

where

$$N = \left(\frac{f_x + f_y}{2}\right)[\alpha(1-\nu) - 1] - \left(\frac{1-\nu}{4}\right)\beta(f_x - f_y) - \frac{A}{b^2}[\alpha(1+\nu) + 1].$$

$$M = \beta\left(\frac{1-\nu}{2}\right)(f_x + f_y) - \left(\frac{f_x - f_y}{2}\right)[\alpha(1-\nu) - 1] - A(1+\nu)\frac{\beta}{b^2}.$$

$$a_0 = a_{-2} = 0.$$

When $\beta = 0$ the cross-sectional area of the

* Mechanical Engineering Department, G.E.C.-Simon-Carves Atomic Energy Group.

† R. Hicks, "Reinforced Holes in Plates," ENGINEERING, vol. 177, page 811 (1954).

reinforcement is constant and the solution of equation (20) gives the following values for the constants

$$A = -\left(\frac{f_x + f_y}{2}\right)\left[\frac{1 + \nu\alpha - \alpha}{1 + \alpha\nu + \alpha}\right]. \quad . \quad (21)$$

$$a_2 = -\left(\frac{f_x - f_y}{4}\right)\left[\frac{1 + \alpha\nu - \alpha}{1 + \alpha\nu + 3\alpha}\right] b^4. \quad (22)$$

$$a_n = 0 \quad \text{when} \quad n \neq 2.$$

Taking $\alpha = 0$, the above expressions give the constants when the hole is unreinforced.

Metals and Materials

STEEL FACTS AND THE FUTURE

Steel production continues to rise, and plans are at last taking shape which should increase supplies of scarce qualities. The July output was a record and production during the first seven months of the year—at a weekly rate of 417,900 ingot tons—was 6½ per cent. above production in the corresponding period of last year. Another welcome development has been the substantial increase in the deliveries of heavy steel products, particularly plate and other heavy rolled material. Plate deliveries were 6½ per cent. higher during the first quarter than in the corresponding quarter of 1956 and 9·3 per cent. higher in the second quarter. Altogether, deliveries to shipbuilding, mining, railways, and building and constructional engineering were 7 per cent. higher in the first half of the year than in the first half of 1956, while deliveries to all other industries were 6 per cent. lower.

The figures, published by the Iron and Steel Board, show that the recovery of demand for cars and household appliances was being translated into demand for sheet in the second quarter of the year. Deliveries were 3·2 per cent. higher than in the corresponding period last year. Should this increase be maintained, as is likely, the pressure on sheet supplies will become such that the strip-mill output of plate will of necessity be reduced (unless the Government direct that it should not be) and it may be difficult to make up the short-fall from imports. The two main points where the highest pressure is likely to be exerted on available capacity is shipbuilding and oil equipment. For this reason the plans recently published by Stewarts and Lloyds are of great interest.

Stewarts and Lloyds have made an arrangement (described as preliminary) with John Summers and Sons whereby hot rolled strip will be supplied by John Summers to an electric resistance weld tube plant to be installed by Stewarts and Lloyds adjacent to John Summers' works at Shotton, near Chester. The new tube plant will have requirements of 100,000 tons of strip initially, rising to 200,000 tons. The output of John Summers' Shotton works will be increased accordingly, so that the necessary tonnage can be made available without reducing the supply to industry of an increased tonnage of cold reduced sheet. This will enable Stewarts and Lloyds to offer to the oil industry some 80 per cent. more tube in 1960-61 than at present.

OPPORTUNITIES FOR NICKEL

There are at present "unmistakable signs," said the chairman of the International Nickel Company of Canada Limited, Mr. John F. Thompson, "that the supply and demand position for nickel is tending to equilibrium more rapidly than anticipated." The extensive expansion schemes of the major producers will, during the next four to five years, raise the free-world production capacity to more than 650 million pounds a year, an increase of 131 per cent. over 1951. International Nickel's own expansion project in Manitoba (Sudbury District) will raise their own annual capacity to 385 million pounds, and will be, according to Mr. Thompson, "the most important single contribution to the enlarged future nickel production."

The acute shortage of nickel which has prevailed since the Korean war to a large extent has been the result of purchases by the United States and British Governments for defence and stockpiling purposes. These have removed some 40 per cent. of total supplies from the market. The rejection by the United States Government of International Nickel's offer of large quantities for delivery in 1960 suggests that it foresees no difficulties in obtaining all it requires at that time. Producers have therefore been left with a major problem when increased output becomes available. The development of new markets is the only possibility, and this Mr. Thompson is confident the industry can do. Research is being carried out into the use of nickel in industries which promise to expand rapidly during the next few years, including atomic energy and gas-turbines. But the prolonged shortage has led to the use of substitutes and to the development of alloy steels containing less nickel or none at all. Demand may not therefore respond quite as quickly to the assurance of increased supplies as producers are hoping, though this should stimulate new developments in the use of the metal.

The Board of Trade's decision to release 1,600 tons of the nickel from the Government stockpile is welcome news for British users. It is equivalent to some 7 per cent. of the annual consumption and will be a great help. Sales will be through Mond Nickel at their normal price and will be spread over from September to June next year. This is a step in the right direction, but some time must elapse before the "open market price"—now about twice that of "regular" nickel—is significantly reduced.

HIGHER PRICES FOR RAW MATERIALS?

The sales of basic industrial raw materials, and their prices, have followed a fairly regular seasonal pattern in recent years. Whether what happened in the autumn of last year and of the year before will be repeated this year depends on a reasonable level of industrial output being maintained in the United States. So far, there is every likelihood that this will be so and that raw material prices will rise sharply as soon as the holiday season has come to an end and business returns to normal.

An analysis of the position in the United States shows that there are factors quite independent from the level of business activity which affect the price movements of all basic industrial materials. These tend to promote hesitancy in the first half of the year and heavy buying in the second half. The summer is "income tax time" with United States industry and there is a general reluctance to spend money even on operations such as stocktaking. It is in the summer also that most of the large wage settlements come into effect, generally accompanied by price increases. Finally, the United States motor industry starts buying in September for the production of next year's new models. Although seasonal patterns in car demand are now less pronounced than they were pre-war, there has been a substantial rise in output in the autumn of both 1955 and 1956.

The last argument, perhaps not very convincing but traditionally correct, is that a prolonged fall in prices is usually followed by a rise. This applies with special force to copper, the price of which fell in the United States last week to 28½ cents a pound. At its peak it was above 50 cents a pound in the free market. Behind all this is the underlying very firm demand for manufactured goods, particularly in Western Europe. Output is still rising in most industries and the mid-term outlook for most materials remains excellent.

GEOPHYSICAL SURVEYS FROM THE AIR

Some interesting details were released recently regarding the progress of geological survey from the air. In 1956 Hunting Geophysics Limited introduced a specially modified D.C.3 aircraft carrying a magnetometer, electromagnetic detector and scintillation counter, developed by their Canadian associates, Aeromagnetic Surveys Limited, all capable of being operated simultaneously, and the equipment has been operated in Europe and Africa. Associated companies in North America and Australia are operating similar installations in Canso aircraft.

Following work in Northern Rhodesia on behalf of the United Kingdom Atomic Energy Authority and Rhodesian Selection Trust, the D.C.3 aircraft has carried out a combined aeromagnetic, electromagnetic and radiometric survey in Cornwall under a contract with the Department of Scientific and Industrial Research on behalf of the Geological Survey of Great Britain and in association with the U.K.A.E.A. To some extent this work was intended to serve as a testing ground in the technique of exploration to be used in less well known areas overseas. By working a reduction unit on a shift system at the flying base it was possible to relate radiometric anomalies to the ground within 24 hours.

Further work for the Atomic Energy Authority will include an aerial survey for radioactive minerals over 6,000 square miles of Southern Rhodesia. The aircraft, carrying recording scintillation meters, will fly up and down the area at a height of 450 ft. in lines a quarter of a mile apart. Areas of strong radioactivity will be surveyed by aerial photographs and later marked on a map. It is hoped that by thoroughly examining the rocks in the areas marked, prospectors may find deposits of uranium minerals. Some very valuable uranium deposits have been found by private prospectors in both Africa and Australia but at the expense of a great deal of wasted effort on the part of the less fortunate prospectors. While preliminary aerial survey may take some of the romance out of prospecting it may well establish a scientific basis on which more economical results can be obtained.

★ ★ ★

HIGH-PURITY SILICON

The news that yet another large company is preparing to produce high-purity silicon in the United States suggests that the fight for the lucrative market believed to exist in the electronics and electrical industries has started in earnest. W. R. Grace and Company, who started as a shipping company and are now large chemical manufacturers, have recently concluded an agreement with the French company, Pechiney, to use the latter's refining process. The Davison Chemical Company of W. R. Grace are setting up a 20,000 lb. plant for the purpose. In the meantime they will market high-purity silicon in the United States imported from Pechiney.

Silicon has probably as high a claim to being a new electrical material as any. Its outstanding semi-conductor properties and high resistance to temperature have ensured that in time it will be used universally for transistors and for a large proportion of rectifiers, replacing particularly the mercury-vapour type and those made from selenium. So far, the United States have led world development and production. Du Pont are probably the largest producers, and have set up a 50,000 lb. plant at Brevard, N.C. Eagle

Picher Corporation, who are important makers of germanium, have recently started producing silicon, and Sylvania Electric Products Corporation make it for their own use and sale. In addition, Texas Instruments, who are the largest makers of silicon transistors, process their own material.

In the United Kingdom, some of the silicon used in the manufacture of rectifiers and transistors is imported from the United States or France. Most of the manufacturers of these products use imported Du Pont material, which has proved itself remarkably even in quality. Johnson Matthey are the most advanced British producers, and expect to be able to supply substantial quantities of high purity material comparable in quality with Du Pont's or Sylvania's. I.C.I. are said to be developing transistor-grade material, but little is known of their progress. Sylvania have recently concluded an agreement with Thorn Electrical and set up a jointly-owned company to manufacture high-purity silicon in this country. The fact that transistor-grade silicon commands a price of 300 dols. a pound (and that it has practically no technical rival) suggests that it is a worthwhile product to develop.

Production

ADHESIVES, EMULSIONS AND COMPOUNDS

NEW FACTORY FOR PRODUCTS WITH MANY ENGINEERING USES

A new factory at Chester Road, Birmingham, adjoining the Fort Dunlop, Erdington, Birmingham, 24, works of the Dunlop Rubber Company, Limited, is now occupied by the company's Compositions Division. Four main groups of product, adhesives, Polimul emulsions, reclaim dispersions and latex compounds, are manufactured by the Division, and the new factory provides facilities for the production and packing of these products in large quantities.

Adhesives, which include the thermoplastic and pressure-sensitive types, have many industrial and engineering uses, besides finding a wide application in building work, for the fixing of floor and wall coverings. A recent development in this field is the production of motor-car body trims with thermoplastic adhesive and electrical heating. Polimul, which is a stable suspension of polyvinyl acetate resin particles in water, forms the basic binding medium for emulsion paints, as well as having many other uses such as a binder, a textile starch and a paper coating. It is the basis of the emulsion paints which have been used, internally and externally, for protection and decoration purposes in the new factory. Reclaim dispersions and latex compounds also have many industrial uses, particularly in the manufacture of carpets and felts.

The new factory is self-contained, with its own laboratories and pilot manufacturing plant, and it is significant of the degree to which scientific control of manufacturing processes has been developed, together with mechanisation of process work, that the number of staff employed exceeds that of the manual workers in the proportion of 1·3 to 1. The laboratory is divided into two sections, dealing with latex and adhesives and with Polimul emulsions respectively, and is backed in the matter of fundamental research by the large Dunlop Research Centre about a mile away. Experimental production work can be carried out in the pilot plant, which is housed in the same building as the laboratories, and contains a variety of equipment, including a rubber mill, a three-roll paint mill, several machines for the manufacture of experimental solutions, a colloid mill, a ball mill, and a Hobart mixer.

The factory proper has a main production area of 21,000 sq. ft., in a building 360 ft. by 90ft., which is designed to be extended at each end. There are three sections in the building, the incoming materials store being at one end and the finished products store at the other, while the main production area lies between the two. Ancillary buildings for production control offices and switch gear are located at one side of the production shop, together with an underground tank farm. A detached boiler house contains a Daniel Adamson super-economic boiler, with Laidlaw Drew oil firing equipment. This boiler is capable of providing 18,000 lb. of steam per hour at 100 lb. per sq. in., the steam being used for process work, including solvent recovery, and for space heating which, in the factory, is by means of radiant panels in the roof. Provision is made in the boiler house for the installation of a second boiler at a later date. A maintenance workshop is housed in the same building as the boiler, together with pumps for the process-machinery cooling water, which is circulated from an 80,000 gallon concrete tank outside the building. Two Visco coolers are provided for use as required.

FIRE PREVENTION

Some of the products handled are highly inflammable, and the whole of the lighting and electric power equipment is therefore of the Buxton-certified flame-proof type, and the fork-lift trucks used for material movement are powered by flame-proof internal combustion engines. Mather and Platt automatic sprinklers are fitted throughout the factory, with emulsifiers over the production machines. As a further safeguard the finished goods area floor level is 1 ft. 3 in. below the main floor, which gives a sunken area sufficient to contain the contents of the drums normally stored there, and so to prevent any flow of burning material into the main production shop in the event of fire.

The building containing the laboratories and offices is of orthodox two-storey steel-framed brick-clad construction, with pre-cast concrete floors. Provision has been made for future extension at one end. Laboratories, the pilot plant and a conference room are on the ground floor, and offices occupy the upper storey. A large canteen, with accommodation for 150 persons, links the two-storey block with the single-storey factory.

The production buildings are of fabricated tubular steel construction, the steelwork having been supplied by Tubewrights Limited. It was erected in an unusual manner. Foundations and flooring for the complete 360 ft. by 90 ft. building were first constructed. These consisted of a set of foundations for the heavier machinery at one side of the building, a concrete raft near the centre for the lighter mixers and other plant, and a 6 in. thick concrete floor over the remaining area. Complete roof spans, each 40 ft. by 90 ft., nine of which form the factory roof, were then fabricated on the concrete floor and lifted, one span at a time, by two mobile cranes to the required height while the tubular stanchions were placed in position. This was a particularly rapid method of construction, the complete roof having been lifted and fixed ready for sheeting in five days. The roof is clad with aluminium decking, insulation board and felt by D. Anderson and Son Limited, and the side walls are bricked to 4 ft. and then sheeted with Turner's asbestos cement sheeting and lined internally. Patent glazing is provided in the northern slopes of the roof. The construction gives a floor which is completely free from obstruction over its entire area of 360 ft. by 90 ft., and the factory is particularly well lighted and ventilated.

The main contractors for the building were George Wimpey and Company, Limited, Birmingham, and James Smith (Builders), Limited, Birmingham.

★ ★ ★

The radiator illustrated with the article on page 792 of our issue of June 21 was referred to as being of stainless steel. We are now informed that the radiator, which was on a transformer made by Transformers (Watford) Limited, was of mild steel.

Two-storey office and laboratory buildings are joined to the main factory area by a large canteen at the new Dunlop compositions factory.

The tubular roof of the main factory was fabricated in 40 ft. spans on the factory floor, and then held up by mobile crane while the stanchions were fixed.

ELAND CONVAIRS FOR BRAZIL

A contract has been signed between D. Napier and Son Limited, and R.E.A.L. S.A. Transportes Aereos, of Sao Paulo, Brazil, for the conversion of three of their piston-engined Convair 340 airliners to take Napier Eland propeller-turbine engines. The contract is worth more than 2,000,000 dols.

R.E.A.L. are the largest airline in Brazil and one of the world's major aircraft operators. They have stated that, after satisfactory operating experience with these first Eland-Convairs, which should all be flying by the end of 1958, they intend to convert the remainder of their Convair fleet—some 20 aircraft in all.

Commencing in August, 1958, R.E.A.L.'s Convairs will be flown one by one to Santa Monica, California, where they will be converted by the PacAero Engineering Corporation, a subsidiary of the Pacific Airmotive Company. Complete power units, including engines, propellers and associated equipment, will be assembled by Napier in England and supplied to PacAero, who will be responsible for their installation and for all airframe modifications.

Napier's own Eland-Convair is now completing its flying programme in the United Kingdom preparatory to being despatched to California in the early autumn for its airworthiness certification by the Civil Aeronautics Administration. Certification will take place under amended regulations which will treat the conversion as a modification of the original aircraft and not as a new type. In their original design the Convair 340 and 440 were stressed to take all-up weights and operating speeds higher than the standard piston engines permit. The fitting of the two 3,500 e.h.p. Napier N.El.6 propeller-turbine engines (which between them provide the aircraft with an additional 2,000 h.p.) allows full economic advantage to be taken of these margins.

PacAero are acting as Napier's agents for the certification programme, and valuable help has been given by the manufacturers of the aircraft—the Convair Division of the General Dynamics Corporation.

In order to accelerate the Eland-Convair project Napier have taken delivery of a Convair 440, which will be flying with Elands early in 1958. The conversion will be carried out at Santa Monica in the same manner as the conversion of R.E.A.L.'s aircraft, and valuable experience will thus be gained.

In due course, Napier's two prototype Eland-Convairs can be made available to operators to help them through their conversion programmes with crew training and route familiarisation, and it has already been agreed that one of the aircraft shall be put at R.E.A.L.'s disposal for this purpose.

The Napier Eland conversion of the Convair 340 airliner has been adopted by R.E.A.L. S.A. Transportes Aereos.

These developments, coupled with the recently-announced formation in the United States of Napier Engines Incorporated, to provide (among other things) overhaul and spares facilities, are calculated to quicken interest in Napier's bid for export sales.

Atomic Review

More Progress Report

LAST week in Atomic Review we gave some extracts taken from two recently published official reports: the *Third Annual Report of the U.K.A.E.A.* and the latest report of the United States Atomic Energy Commission. This week we give extracts from two more such reports, the first by the United Nations (particularly do we quote the report on U.S.S.R. developments) and secondly that of the European Organisation for Nuclear Research (CERN).

U.N.—U.S.S.R.

The Economic and Social Council of the United Nations has assembled a comprehensive document, *Economic Applications of Atomic Energy: Power Generation and Industrial and Agricultural Problems* (to be available from H.M.S.O., price 3*s.* 6*d.*). The report broadly surveys the potential benefits of atomic energy and its present development. Details taken from the preliminary limited edition are given below. Part 1 of the report is divided into three chapters: the first assessing the rôle of nuclear energy as a source of electric power, the second listing industrial uses of radioactive materials and radiation, and the third dealing with the potential contribution of atomic energy to development in agriculture and related industries. There is also a table noting data on nuclear power plants under construction or authorised in six countries (those mentioned below plus Brazil). Part 2 is mainly devoted to replies to a questionnaire on power needs, current nuclear work, and factors conditioning choice between nuclear and conventional power sources, submitted to the governments of Canada, France, the Union of Soviet Socialist Republics, the United Kingdom and the United States. There are also a number of annexes reporting, for example, on kilowatt-hour requirements in various fields of activity, and known uranium reserves and production of uranium oxide. The following note contains items selected from the reply by the Soviet Government to the questionnaire.

Soviet Power Plans

Although the Soviet Union is well supplied with conventional power resources the bulk of these (over 70 per cent.) are situated in the Asian territories of the U.S.S.R., whereas much of the power demand (four-fifths of the total) is located in the European regions. To compensate for this distribution and to minimise fuel transport costs, early construction of nuclear power stations is to be concentrated in the Urals and the European areas of the Soviet Union. For safety, sites are to be some 30 to 40 km. from large towns with a housing clearance zone of 3 km.; for this reason none of the initial power stations will be used for district-heating purposes. Another object of this first stage will be to provide experience of design and operation, together with information as to nuclear power prospects. The capacity of the stations to be built is given in the present report as 200 MW each.

Soviet Nuclear Power Stations

Two of the stations (Project 1) to be built under the Ministry of Electric Power Stations plan will have water-moderated and water-cooled reactors. A two-circuit system has been adopted. The water in the primary circuit, at 100 atmospheres pressure (1,470 lb. per sq. in.), is heated in the reactor from 250 deg. C. to 275 deg. C. and passes into the steam generator, where it transfers the heat derived from the reactor to the water and steam in the secondary circuit. The water in the primary circuit is then pumped back from the steam generator into the reactor. The secondary circuit is analogous to the steam-water circuit of a conventional thermal power station, and performs the functions of supplying steam to the turbines and returning the condensate to the steam generator. The turbo-generators (three of 70,000 kW each) will be driven by saturated steam at 30 atmospheres pressure (440 lb. per sq. in.) from one reactor. A separator to remove moisture from the steam used in driving the turbine will be installed between the two cylinders of the turbine, thus ensuring that the steam is at the correct humidity in the final stages of expansion.

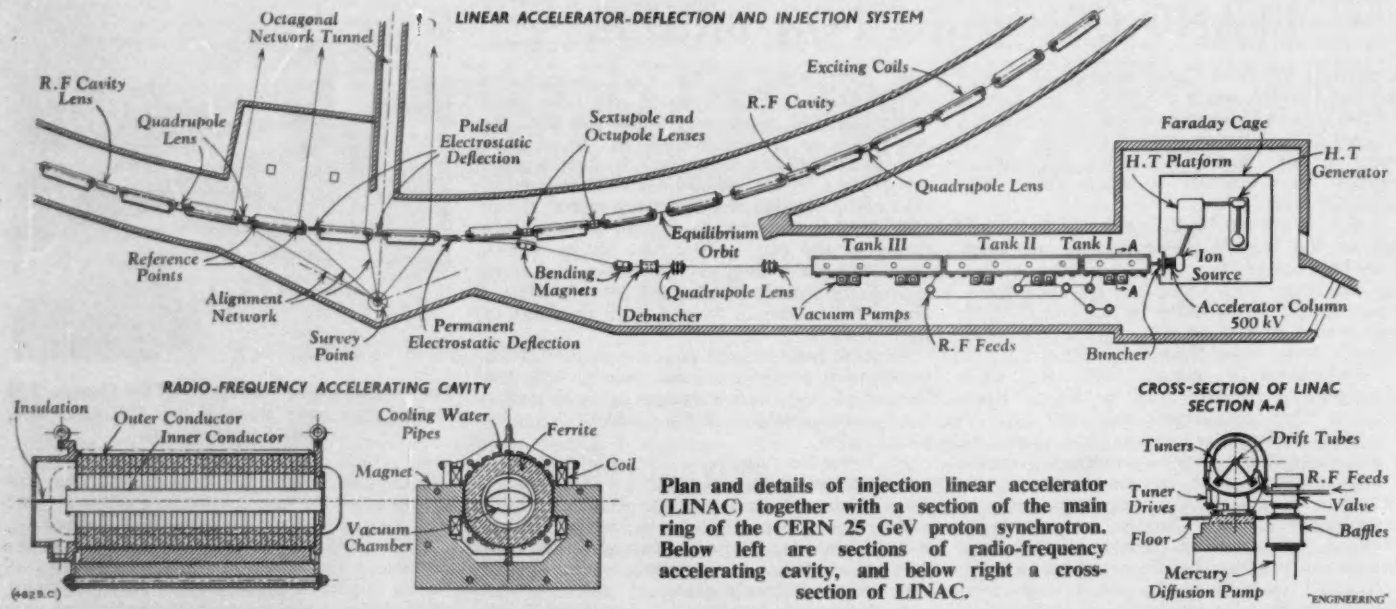
In water-moderated reactors, part of the charge must consist of enriched fuel, and the mean enrichment of the uranium used to fuel the atomic power station reactor under consideration is accordingly kept to about 1 per cent. It is expected that in a reactor operating on thermal and some epithermal neutrons a very high rate of fuel burn-up will be possible, with a breeding ratio of the order of 0·8. Spent fuel will be sent for chemical processing for extraction of the accumulated plutonium. It is calculated that there will be enough of this plutonium to supply the reactor with all the enriched material required for the next charge; thus it is possible that uranium-235 will be needed only for the initial charges.

A third power station (Project 2) is to be equipped with reactors similar to that used in the first atomic power station of the Academy of Sciences of the U.S.S.R., which is in operation. (It is stated that, since this station started up in July, 1954, no faults have occurred in the fuel elements.) These will be graphite-moderated, and the heat transfer media will be water and steam circulating through channels in the reactors. Some of the channels will be used for superheating the steam in the primary circuit to approximately 540 deg. C. The heat taken from the reactor by the steam will be used in the steam generator to produce and superheat secondary steam, which will then be fed into the turbines. High-quality secondary steam—90 atmospheres (1,320 lb. per sq. in.) and 500 deg. C.—is expected to be produced; modern turbines designed for such parameters, with a power of 100 MW each, will be used at this station. For the plants to be built by the Ministry of Electric Power Stations, the planned fuel-utilisation figures are 2,500 to 3,500 MW days per ton. Details of the two types of project are listed in Table II, at the foot of page 284.

Soviet Experimental Power Plants

In addition to the large-scale power stations, it is planned to construct four relatively small power plants with reactors, of between 5 and 70 MW capacity, requiring thorough experimental study before they can be recommended for use in large power stations. These power plants are intended for research purposes.

At one of the plants (Project 3) it is proposed to install a boiling-water reactor using water as moderator and heat-transfer medium. The steam fed into the turbine will be generated in the reactor itself, and the plant will thus function on the single-circuit principle. The steam entering the turbine will be radioactive, and all service operations on the turbine must accordingly be carried out by remote control. The operation of the plant is intended to provide information on the stability of a reactor where the moderator has a high and fluctuating steam content, and on the conditions to be met where turbine equip-



Plan and details of injection linear accelerator (LINAC) together with a section of the main ring of the CERN 25 GeV proton synchrotron. Below left are sections of radio-frequency accelerating cavity, and below right a cross-section of LINAC.

ment is not accessible for direct servicing.

Another (Project 4) of the experimental power plants will be equipped with a graphite-moderated reactor, using molten sodium as heat-transfer medium. The use of sodium will enable the plant to generate high-quality steam, which will be used to drive the turbine. The plant is designed to provide experience in the operation of the sodium cooling system; at the same time it will indicate the neutron-physics characteristics of the sodium graphite reactor.

The third type of reactor (Project 5) to be used at one of the experimental power plants is a homogeneous thermal-neutron reactor moderated by heavy water. The reactor will be of the boiling-water type, with natural circulation, and will be fuelled by a solution of uranium salts in heavy water or a suspension of fine powder. It is being built in order to provide data on the characteristics of breeding by the thorium 232-uranium 233 cycle and on the possibilities of using a stationary system for separating the slag.

The fourth experimental plant (Project 6) is being equipped with a fast-neutron reactor, designed to operate as a breeder by the uranium 238—plutonium 239 cycle. In the research to be carried out in this reactor, breeding problems will be given first place. One of the accompanying problems to be solved is that of ensuring heat transfer under conditions of extremely high heat flow due to the very compact reactor design inherent in the system chosen. Research for Project 2 is being carried out in the channels and a number of special loops in the first power station, while the reactor for physical and technical research (RPT) is providing information for Projects 1 and 3.

CERN

Last month the European Organisation for Nuclear Research (CERN) published its *Second Annual Report*. Reference to CERN projects has previously been made in Atomic Review on June 22, August 10 and October 12, 1956. The following is an account of the organisation's work during 1956.

At the end of 1955, apart from cosmic-ray research on the Jungfraujoch and the work of the theoretical study division in Copenhagen, CERN's activities were entirely directed towards the construction of its two accelerators, the 600 MeV synchro-cyclotron and the 25 GeV proton synchroton, on the Meyrin site near Geneva. During 1956 the work of construction advanced considerably, in accordance with the programme; the synchro-cyclotron is practically complete, with the exception of the high-frequency system. Work on the proton synchrotron progresses: the buildings are nearing completion, the specifications for all main components of the machine have been drafted in their final form, and orders have been placed for the majority of them.

CERN is entering a new phase of research, and measures have been taken to anticipate the use of the synchro-cyclotron which is to come into operation in 1957. (Since the *Annual Report* was published it has been officially announced that the machine has been working at its peak output energy of 600 MeV.) A programme of experiments has been established and studies have been made in the internal organisation necessary to carry this programme out. Means and methods have been suggested whereby graduates, either individually or in teams, from member states can be enabled to make the best use of the machine and CERN's facilities. The problems involved have been examined by the Scientific Policy Committee, whose recommendations will be considered by the Council during the first half of 1957, when it is expected that final decisions will be taken. The recruitment of the theoretical group at Meyrin, which is to take over from the division in Copenhagen in October, 1957, is proceeding. In the field of equipment, the set of two cloud chambers has been successfully completed by the scientific and technical services division and will be used for experiments on K-mesons.

CERN delegations led by the director-general went to Rochester (U.S.A.) in April and to Moscow in May, and CERN itself organised a symposium in June, 1956, on high-energy accelerators and pion physics, which was held at Geneva. The success of that gathering has encouraged CERN to make plans for a similar one in 1958, and it is hoped that it will then be possible to welcome participants in the new main building at Meyrin.

Advances in research revealed at the Symposium on new principles for the acceleration of particles, particularly by the United States and the Soviet Union, prompted the decision to set up within the proton synchrotron division a new section to carry out its own research in this field. The CERN staff has increased from 260 on December 31, 1955, to 396 on December 31, 1956, and to this latter figure should be added 8 half-time workers, 14 consultants, and 22 fellows.

Proton Synchrotron

Considerable information is given, in the report, on the 25 GeV proton synchrotron, the layout of which was shown in a general plan of the Meyrin site in Atomic Review on October 12, 1956; a drawing representing a section of the roughly 220 metre diameter ring and details of the magnetic units appeared in Atomic Review on June 23, 1956. Drawings of the injection linear accelerator (LINAC) showing the deflection and injection system, together with sections of a radio-frequency accelerating cavity, are reproduced in the drawing above.

Acceleration by Pinch Effect

An idea discussed in the CERN report and only given passing mention in an earlier Atomic Review (June 22, 1956) was a revolutionary new principle for the acceleration of particles put forward by scientists from the Soviet Union. Their proposal consists of accelerating the particles (protons) in a toroidal plasma of high current density, in which the electrons have relativistic velocities. Their theoretical work predicts that due to the pinch effect, magnetic fields of the order of 10^6 gauss might be realisable. If such high fields were attained, protons in the plasma of an energy of 100 GeV could be held in an orbit of approximately three metres radius. Experiments are being carried out with high-intensity toroidal electron beams, which later on will be neutralised by positive ions. If this new principle can be achieved in practice it will certainly offer attractive additions

TABLE II.—Details of the Nuclear Power Stations to be Built in the Union of Soviet Socialist Republics (preliminary data)

Description	Units	Name of project	
		Project No. 1	Project No. 2
Capacity:			
thermal	MW	1,520	1,150
electrical (gross)	MW	420	400
electrical (net)	MW	390	375
Calculated number of hours of use at full capacity	hours per year	7,500	7,500
Type of reactor	—	moderator and coolant: pressurised water	moderator: graphite; coolant: pressurised water and steam
Fuel charge	tons	40	185
Average enrichment	per cent.	1	1·2
Calculated burn-up, MW days	per ton	3,500	2,500
Pressure and temperature of coolant on leaving reactor	atmospheres	100	160
	deg. C.	275	540 (steam)
Pressure and temperature of steam in secondary circuit (before turbines)	atmospheres	30	90
	deg. C.	230 (sat. steam)	500 (superheated steam)

to the present types of accelerating machines. Since such machines involve the study of plasma physics there is some interlocking of interests between physicists working on these machines and those engaged in controlled thermonuclear research.

General Notes

Power from Sub-Critical Reactors

A scheme has been reported in *Nucleonics* (June) whereby any reactor could operate sub-critically. Proposed by Professor Lyle B. Borst, head of the physics department, New York University, the scheme makes use of a device called a Convergatron, designed to maintain the neutron flux in the sub-critical reactor at a level determined by the contribution from a small external neutron source. This source would thus serve to control or shut down the reactor. A sub-critical reactor might be described as a neutron amplifier, since for every n neutrons introduced from outside, $\frac{n}{(1-k)}$ are produced, where k is the reactivity. The Convergatron would comprise a series of sub-critical systems so arranged that the neutrons produced in one system act as source neutrons for the next; the initial input would be a controllable neutron source, say a radium-beryllium source. The Convergatron would supply neutrons to the main reactor (itself sub-critical, having a reactivity of about 0·95). Each stage of the Convergatron (there might be eight, each a foot wide) would comprise, in the order given, three regions—(1) a neutron moderator, (2) fissile fuel, and (3) a thermal neutron barrier such as cadmium. It will be clear that fast neutrons alone proceed from one stage to the next (since thermal neutrons are halted by the barrier) and these will be moderated before entering the next fuel region. More fast neutrons will be produced by fission in the fuel for transmission to the succeeding stage, and so on.

Supporting Skirts for Reactor Pressure Vessels

"Supporting Skirts for Reactor Pressure Vessels" is the title of a paper prepared by Dr. Raymond Hicks of the mechanical engineering department of the G.E.C.—Simon-Carves Atomic Energy Group, Erith, Kent. It deals with one of the structural engineering problems encountered during the design of a reactor pressure vessel for the nuclear power station to be built for the South of Scotland Electricity Board (see Atomic Review, December 21, 1956, and February 8 and 15, 1957). It is shown how a general solution was obtained to give the moments and shear forces induced in the vessel and its supporting skirt due to the various types of loading imposed on the structure during fabrication and under full operating conditions.

Nuclear Powered Aircraft Carrier

It has been reported that the United States Navy has placed an order for the construction of an 80,000 ton aircraft carrier powered by nuclear means. Intended to run for 5 years without refuelling and due for completion in 1961, the carrier will have a 1,088 ft. over-all flight deck and will cost about £107,142,000.

Irradiated Cables

British Insulated Callender's Cables Limited announce the manufacture of a selected number of types of small coaxial radio frequency cables insulated with irradiated polythene. The polythene insulation is irradiated so as to reduce greatly deformation during soldering of the core, but otherwise the cables are of a standard construction. Although the power factor is slightly increased, other electrical characteristics are virtually unimpaired, and the cables are recommended for normal R.F. applications at frequencies up to 200 Mc/s. In addition, irradiated polythene equipment wires with improved soldering properties are now available together with a similar type of wire which is also satisfactory for continuous operation up to 100 deg. C. The latter type may be operated at 120 deg. C. for 1,500 hours and for shorter periods (approximately 1 hour) up to 250 deg. C., provided that care is taken to ensure that the insulation is not placed in contact with bare copper.

APPR Completes 700 Hours

A 700 hr. performance test of the Army Package Power Reactor at Fort Belvoir, Virginia, has been successfully completed by Alco Products Incorporated, which built the plant for the Atomic Energy Commission and the United States Army Corps of Engineers. The power plant operated at a load designated by the Commission for a period of 700 hours, during which shutdowns totalling only eight hours were required for adjustment and repair of plant components. During more than 600 hours of the test, electricity was generated at a rate exceeding the design output of the plant. A total of 1,181 MWh of electric power was produced during the test. This amount of electricity would be sufficient to satisfy the needs of 300 to 400 homes for one year.

The 2 MW APPR is the prototype for nuclear plants of up to 20 MW being marketed outside the American continent by Humphreys and Glasgow Limited, of London. With European manufacturing costs and a recent reduction in the cost of re-processing fuel elements, the company estimates that a 10 MW plant of this type would generate electricity at between 1*d.* and 1½*d.* a unit.

Accelerator for CERN

Part of a 50 MeV proton linear accelerator for CERN was despatched to Geneva last month from the Trafford Park Works of Metropolitan-Vickers Electrical Company, Limited. The linear accelerator, when completed, will be 100 ft. long, and the item despatched is a 40 ft. long, 9 ton section of the steel vacuum tank.

Course

"Concrete and Nuclear Radiation Shielding" is the subject of 10 lectures to be held on Monday evenings from 7 until 9 p.m., commencing September 30, 1957. The course is one of a number of post-graduate evening courses being presented by the Department of Civil and Mechanical Engineering, Battersea College of Technology, and the lecturer in this case is Mr. D. A. Howells. Enrolment forms may be obtained from the Secretary (C. and M.E. Courses), Battersea College of Technology, Battersea Park-road, London, S.W.11, and the fee is £1.

BICEP

An experimental facility designed to provide the British atomic energy consortia with information on reactor-core fluxes and on lattice dimensions and arrangements is reported to be in preparation at Harwell. Known as BICEP, the British Industries' Co-operative Exponential Pile project will be based on an exponential experiment built to allow easy variation of cooling-channel size, lattice pitch and the details of fuel elements.

Zero-Energy Reactor Contract

The General Electric Company, Limited, has been awarded a contract by the United Kingdom Atomic Energy Authority for a large part of the design and construction of a Zero Energy Assembly for an entirely new type of gas-cooled reactor. The equipment will be built at the Authority's proposed new research station at Winfrith Heath. This Zero Energy Assembly is the first stage in the development of a high-temperature reactor system in which fuel temperatures will be raised well above those possible in present designs. The resultant higher gas temperature would then enable electricity to be produced more efficiently by conventional steam turbo-generator plant or possibly by gas-turbines.

The assembly will be used primarily to examine the nuclear properties of the system and to verify design calculations before proceeding to a power reactor. It is so designed that the nuclear reactions will take place at a very low rate and very little external radiation or heat will be produced. Hence the term "Zero Energy."

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
"Any Questions?" North East London Branch. Angel Hotel, Ilford. Mon., Sept. 2, 8 p.m.
"Instrumentation of Industrial Boiler Plant," by L. F. Cohen. South East London Branch. Eltham Congregational Church Hall, Court-road, S.E.9. Tues., Sept. 3, 7.15 p.m.
"Safety Precautions on Building Sites," by J. A. Haywood. West London Branch. Windsor Castle Hotel, Hammersmith, W.6. Tues., Sept. 3, 7.30 p.m.
"Earth Leakage Equipment," by J. Robbins. North London Branch. Queen's Head, 677 Green-lanes, Harringay, N.4. Wed., Sept. 4, 7.15 p.m.
GLASGOW
Film Evening. Programme including "The Cathode Ray Tube." Glasgow Branch. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Wed., Sept. 4, 8 p.m.
LIVERPOOL
Chairman's Address, by A. Robertson. Liverpool Branch. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Fri., Sept. 6, 6.30 p.m.
MANCHESTER
"The Modern Diesel Engine," by T. E. Draper. Manchester Branch. Engineers' Club, Albert-square, Manchester. Wed. Sept. 4, 7 p.m.
PRESTON
"Fire-Fighting and Accidents in the Home," by O. C. Budd. Preston Branch. R.A.F.A. Club, East View, Preston. Wed., Sept. 4, 7.30 p.m.
SHEFFIELD
Chairman's Address. Sheffield Branch. Royal Victoria Station Hotel, Sheffield. Mon., Sept. 2, 7.15 p.m.
SOUTHAMPTON
"Electrical Accidents and Factory Regulations," by S. J. Emerson. Southampton Branch. Polygon Hotel, Southampton. Thurs., Sept. 5, 8 p.m.

Incorporated Plant Engineers

LONDON
"Maximum Demand and the Power Factor, and their Effect on the Electricity Tariff," by T. A. Williams. London Branch. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Tues., Sept. 3, 7 p.m.*
CHESTER
"The Cost Accountant and the Plant Engineer," by R. G. Hall and B. J. Willson. Mersey and North Wales Branch, The Blossoms, City-road, Chester. Mon., Sept. 9, 7.15 p.m.
DUNDEE
Discussion on "Variable Speed Drives with Voltage Regulation Equipment." Dundee Branch. Mather's Hotel, Dundee. Mon., Sept. 9, 7.30 p.m.
EDINBURGH
Open Meeting. Edinburgh Branch. 25 Charlotte-square, Edinburgh. Tues., Sept. 3, 7 p.m.
LEICESTER
"The Painting of Buildings," by R. Woodwards. Leicester Branch. Bell Hotel, Leicester. Wed., Sept. 4, 7 p.m.

Institute of Petroleum

LONDON
"Some Developments in Marine Drilling Foundations," by A. Kranendonk. Wed., Sept. 4, 5.30 p.m.*

Institution of Engineering Designers

NEWCASTLE-UPON-TYNE
Chairman's Address, by J. Teasdale; and an informal discussion on "Branch Affairs." North-East Branch. Northern Architectural Association's Hall, 6 Higham-place, Newcastle-upon-Tyne. Mon., Sept. 9, 7.15 p.m.

Institution of Production Engineers

COVENTRY
"Changing from Batch to Flow Production," by H. C. Blackford. Coventry Graduate Section. At works of the British Piston Ring Co., Ltd., Holbrook-lane, Coventry. Wed., Sept. 4, 7.15 p.m.

Royal Aeronautical Society

LONDON
45th Wilbur Wright Memorial Lecture on "Advanced Education and Academic Research in Aeronautics," by Dr. Clark B. Millikan (of the Guggenheim Aeronautical Laboratory, California Institute of Technology). Institution of Civil Engineers, Great George-street, S.W.1. Fri., Sept. 13, 6 p.m.*

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

*** An asterisk is placed where it is understood that tea is available prior to the time stated.**

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
Incorporated Plant Engineers, 12, The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institute of Petroleum, Manson House, 26 Portland-place London, W.1. (LANgham 2250.)
Institution of Engineering Designers, 38 Portland-place, London, W.1. (LANgham 8847.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)

Automobile Engineering *By Gordon Wilkins*

AUTOMOBILES AND ENVIRONMENT

It is discouraging for the engineer to find how often the benefits of technical progress are nullified by factors over which he has no control. In 25 years the speed of civil aircraft has trebled, but the time for the journey from London to Paris remains unchanged, because of the increased delays on the ground. On the railways it has taken 20 years to knock three minutes off the time from Glasgow to London, and our train speeds are still far below the maxima achieved a hundred years ago. On the road, despite all the progress made by the automobile engineer, we are rapidly approaching complete stagnation; in fact it has already arrived at some points.

For quite a moderate price one can now buy a car capable of reaching 100 m.p.h.—an aspect heavily stressed by Dr. W. H. Glanville, of the Road Research Laboratory in a paper* to the Royal Institution which received a good deal of publicity some time ago. Dr. Glanville dwelt upon the problems of stopping a car from 100 m.p.h., particularly in the wet. He added that speeds on the road are rising—an average of one mile per hour each year—and concluded gloomily "there is no possibility of improvements in the road keeping pace with the increasing performance of the car." Unlike many of Dr. Glanville's objective announcements, this one must have been welcome news for those politicians and Treasury officials who are always seeking new excuses for not building roads, and has no doubt played a part in fostering the Government's intention to impose a speed limit on the new motor roads if and when these are built. A limit as low as 70 m.p.h. in daylight and 55 m.p.h. at night is proposed, which means that even the drivers of the baby cars of the immediate future will have to divide their attention between the road and speedometer—a thoroughly undesirable state of affairs.

Maximum speeds on short stretches of open road may be increasing, but total times for journeys are also increasing. One can motor for years and cover tens of thousands of miles in England without ever seeing a car doing 100 m.p.h. A truer picture of British road conditions was presented by the checks on the Portsmouth road in 1955, which showed that the average cruising speed of all cars was 38·4 m.p.h. and only 1 per cent. of vehicles exceeded 60 m.p.h. On motor roads in Continental Europe and in the United States, a cruising speed of 65 m.p.h. enables one to cover 60 miles in an hour. On most English main roads, it would be necessary to cover considerable distances at 80–90 m.p.h., with bursts up to 100 m.p.h. to achieve 60 miles in an hour and the feat is beyond the capacity of the great majority of drivers, regardless of the vehicle employed. It is facts like these, and the growing number of people who are staying at home at week-ends rather than spend their time sitting in traffic blocks, which illustrate the underemployment of our automotive resources. The 100 m.p.h. motorist is no problem in this country. The threat to our national life is more accurately expressed by another of Dr. Glanville's pronouncements: that for every mile an hour drop in traffic speed caused by road congestion, the nation loses £30 million a year.

Mr. C. G. Coles of the Road Research Laboratory has said "the provision of a sufficiently high skidding resistance to meet the maximum performance of the modern car when braking in wet conditions presents a virtually insoluble problem for the highway engineer" and the modern car can utilise to the full the maximum friction that can be developed by radial accelerations when taking bends other than those of large radius.

Unfortunately 10 per cent. of our main roads still give less than the minimum tolerable braking force coefficient in wet weather (0·22 at 60 m.p.h.) and very little has been done to provide roads where the driver is not constantly confronted with emergencies which may lead to skidding. The work of the Road Research Laboratory on the means by which a tyre grips the road in wet weather is fairly well known; effective piercing of the film of water between tyre and road depends on the sharpness of the stone particles in the road and the drainage paths available. Some stones are quickly polished to a rounded form; hence the roads which seem to have a safe black matt surface, but prove treacherous when wet. With a fast car there may not be time for the water film to be pierced, so that the car rides on a continuous water film. Smooth tyres are popularly regarded as dangerous in wet weather, but they are mainly dangerous on poor roads. To quote from Dr. Glanville's R.I. paper "If the road already has an open texture so that it already provides drainage paths, then there is less need to have them on the tyre, and on such a road a smooth tyre can be as safe as a treaded one."

The automobile engineer can help to minimise the effects of accidents by producing cars which do not allow the occupants to be thrown out easily on impact; better door locks are only part of the answer; people may still be thrown out through the burst body or the roof, and then the kinetic energy, instead of crumpling the car, has to be absorbed by the victim's body sliding along the road. Well-designed safety belts obviously help, but a big educational job must be done to persuade the public to use them.

* "Speed on the Road and Related Effects," delivered on Nov. 30, 1956.

ACTIVITY IN THE GERMAN MOTOR INDUSTRY

With the Frankfurt Motor Show only five weeks away, the German motor industry is beginning to reveal the models on which it will rely to maintain its place as the world's greatest exporter, against British competition.

The usual shrewd assessment of the features that count with the car buyer marks the improvements to the Volkswagen which took effect on the production lines from August 1. These include a larger rear window, with about twice the previous area, and a larger windscreen providing a greater degree of forward vision. The roller accelerator pedal is replaced by a rubber-covered treadle, and revised leverages reduce the effort required on the brake pedal. A redesigned instrument panel provides a larger glove box and the doors have a plastic trim which is easier to clean than cloth. The improvements to screen and rear window were presumably made possible by a need to renew tools for the roof panel.

Several changes are announced for Mercedes in 1958. The type 180 gets an overhead camshaft engine of 1,897 c.c. in place of the former 1,767 c.c. side valve unit, giving a 25 per cent. increase in power, but compression ratio is held at 6·8 : 1 to permit use of low-grade fuels. The 190, with same body but more luxurious equipment, retains 7·5 : 1 compression giving an extra 10 h.p.

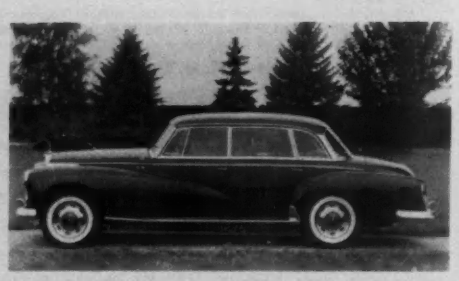
Detail improvements to all cars include new upholstery cloth, duo-tone door trim, padded sun visors, rear number plate lighting built into the bumper overriders and a flexible mounting for the Mercedes star on the radiator, to prevent injuries to pedestrians which could be caused if the star broke off in a collision.

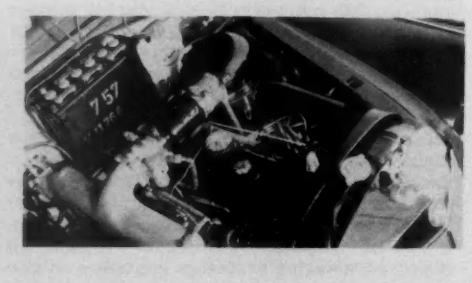
On both 219 and 220 S, compression ratio has been raised to 8·7 : 1 and a new camshaft gives increased torque. On the single carburettor version of this 2,195 c.c. 6-cylinder engine, as used in the type 219, maximum power is now 100 b.h.p. (S.A.E.) at 5,000 r.p.m. and torque is raised by 9 per cent. to 130 lb.-ft. (S.A.E.) at 2,700 r.p.m. On the twin carburettor engine in the 220 S, maximum power is 120 b.h.p. at 5,200 r.p.m., and torque is up by 7 per cent. to 137 lb.-ft. at 3,600 r.p.m.

Optional on both these cars is the Hydrak automatic clutch giving two-pedal control. This consists of a fluid coupling, combined with a single-plate clutch which is freed by a vacuum servo operated by electrical contacts in the gear lever. There are several interesting features in the system. A free-wheel between driving and driven sides of the fluid coupling locks up the drive on the overrun, so that full engine braking is available downhill; the car can be parked with the engine in gear for extra safety on steep slopes and a cold engine cannot stall at low road speeds. There is also a switch on the rear axle worked by torque reaction to regulate the engagement of the friction clutch so as to avoid a jerk when downshifts are made on a closed throttle.

The new body of the Type 300 combines the aristocratic styling of the Mercedes-Benz town carriage with the advantages of the popular American four-door hard top. Centre pillars stop short at the waistline, and all side windows and rear quarter lights with their chromium-plated frames, can be wound down out of sight, leaving all-round vision unbroken save for the front ventilating panes, the screen pillars, and the two slim pillars which support the roof canopy at the rear.

Wheelbase has been increased by 4 in. to 120 in. to provide more legroom. The trunk is bigger and in the rear wings are grouped tail lamps, direction indicators, stop lamps and reversing lights. The longer wheelbase and the body reinforcement necessitated by the cut-down centre pillars have helped to increase kerb weight by about 190 lb. to 4,400 lb., but this is more than offset by the increase in engine power and torque. Size of the six-cylinder overhead camshaft engine remains unchanged at 2,996 c.c., but compression is raised to 8·55 : 1 and Bosch fuel injection takes the place of the twin carburetters, raising gross horsepower by over 30 per cent. to 180 b.h.p. at 550 r.p.m., and maximum gross torque by 10 per cent. to 191 lb.-ft. at 4,500 r.p.m. Whereas the 300 S and 300 SL sports engines have direct injection





The Mercedes-Benz 300 has been re-styled and the power raised to 180 b.h.p. The Bosch fuel-injection system now feeds into the inlet ports.

The 600 c.c. Lloyd "Alexander" has redesigned suspension and an optional synchromesh gearbox.

Redesigned by Zundapp, the "Janus" now has normal doors and independent rear suspension.

into the combustion chambers, the 300 has indirect injection into the inlet ports, but it is still timed by the same type of Bosch pump. The new location presumably reduces service requirements on the injectors. The control system adjusts fuel quantity to engine load according to inlet depression, compensates for variations in ambient air temperature and pressure, gives automatic enrichment for a cold start and provides for a fast idle on a cold engine. Fuel is supplied by a plunger pump, but there is an electric primer pump which is automatically cut out by an oil-pressure switch when the engine fires. It can be brought into use by a dashboard switch in the event of vapour lock arising.

Improvements have also been made in the Borg-Warner torque converter transmission (now standard equipment) with the object of improving acceleration. Second gear is normally used for starting, but the kick-down now brings first speed into use for initial getaway and it can be obtained by the kick-down at any speed below 25 m.p.h. There is also a new locking device which holds the car when it has been stopped on a gradient until the accelerator is pressed again. Rear axle ratio remains unchanged at 4·67 : 1 but, to give extra acceleration for American conditions, a 5·11 : 1 axle goes on cars shipped to the United States.

Other items in the Daimler-Benz programme are a new city bus with a self-levelling air suspension, and a long wheelbase version of the Unimog four-wheel drive cross-country vehicle.

Opel have just announced a new Rekord saloon and station wagon, and later Ford of Cologne will present their new 17M model, a car similar in size and design to the Ford Consul.

Activity is intense in the miniature car field. The 600 c.c. front-wheel drive Lloyd, which holds third place in German sales after Volkswagen and Opel (production of this and the 400 c.c. two-stroke model totals 250 a day) has been given winding instead of sliding windows and external access to the luggage locker. The front suspension, by twin transverse leaf springs, has been redesigned to give a softer ride and a progressive rate, and the peculiar rear springing by swing axles with half elliptic springs has been redesigned. The front end of each spring is now carried on a ball joint and the rear hangs from a bonded rubber link. The two-cylinder air-cooled four-stroke engine with its overhead camshaft and roller bearings remains unchanged, but for £17 extra a four-speed all-synchromesh gearbox can be had in place of the standard three-speed non-synchromesh box.

Having built some 600,000 motor cycles and scooters, Zundapp were very conscious of the recession taking place in the German motor-cycle and scooter market, and some time ago they took steps to broaden their interests by acquiring the rights in the Dornier-Delta prototype, a back-to-back four-seater baby car with front and rear doors. It has since been redesigned and is now in production in a re-equipped factory, where considerable sums have been spent on the installation of presses, paint booths and ovens, spot-welding jigs and production lines. The lift-up doors on the Dornier have given place to doors with normal opening at each end, similar to the front doors on the Isetta and Heinkel. Front wheels are carried on swinging arms projecting forward from pivots under the front seat, where they are joined by an anti-roll torsion bar. Steering is by rack and pinion. Rear suspension is independent, using a layout similar in principle to that of the Goggomobil. The driveshaft is one arm of a wishbone and the other arm projects forward to a pivot on a cross-member under the rear seat. Suspension media at front and rear are coil spring-damper struts inside the wheel boxes. The engine is a fan-cooled single-cylinder two-stroke of 248 c.c., lying on its side in the wedge-shaped space enclosed by the back rests of the seats. It gives 14 b.h.p. at 5,000 r.p.m. Housed alongside it are fuel tank and spare wheel. The makers give the dry weight as 935 lb.; maximum speed 50 m.p.h.; and fuel consumption as 51 miles per Imp. gal. when the speed is kept at a steady 37 m.p.h.

N.S.U. will probably reveal their new miniature car early in September and B.M.W. are expected to reveal a new four-seater small car about the same time.

Construction

BRITAIN'S PART IN IRRIGATION AND DRAINAGE

Most people are aware of the lead taken by British engineers in the development of the extensive irrigation systems in India, Pakistan, Ceylon, Egypt, the Sudan and elsewhere; in the building of the great river-control works that serve them; and in the production of the machinery and materials required for their construction and maintenance. The knowledge thus accumulated during the past hundred years or so is now available to the numerous countries in Africa and the East that are striving to increase their food supplies by means of new irrigation and drainage undertakings. These countries, in their turn, widely value the experience which British engineers possess.

As is generally known, a prominent share in the planning of works of this kind is being undertaken by such international bodies as the World Bank, the United Nations Food and Agriculture Organization, and the Columbo Plan countries. Although it is not easy to evaluate the amount of work likely to be involved in these schemes, one recent estimate has led to a belief that at least twice as much large-scale engineering work for irrigation and drainage purposes will be needed in the coming 50 years as was effected during the past half-century. Such work will involve, of course, not only civil-engineering construction, in the form of dams, barrages, canals and drains, but also the production of a wide variety of mechanical-engineering equipment. Moreover, many surveys will be required, as well as of land levels and topography and of soil characteristics; and in these investigations air-surveying firms will have a part to play.

It is in these circumstances that the establishment a few years ago of the International Commission on Irrigation and Drainage is of special interest, in that the organisation provides a means for both engineers and manufacturers to keep in touch with what is happening overseas. The Commission supplies its members with information concerning the physical conditions and engineering methods prevailing in any country concerned in irrigation or drainage projects. These facilities, naturally, could also be useful to land-drainage engineers in Britain anxious to keep themselves well-posted in overseas techniques or seeking to prepare themselves for positions abroad.

The activities of the Commission culminate in international congresses held at intervals of three years. This year's congress took place at San Francisco in April. Including Great Britain, the present membership of the Commission comprises a total of 37 countries and there is a British Section, the headquarters of which are at the Institution of Civil Engineers, Great George-street, London, S.W.1. Membership of the British Section is in two classes: corporate, with a minimum subscription of 10 guineas a year; and individual, with a minimum subscription of 2 guineas a year. Every member receives a free copy of the annual bulletin which the Commission publishes.

SCAFFOLDING TECHNIQUE FOR COOLING TOWERS

By making use of an unusual form of access scaffolding, it has been possible for the contractors at Castle Donnington Power Station, near Derby, to complete the fourth cooling tower shell (height 310 ft., base diameter 212 ft., neck diameter 117 ft. 6 in., and top diameter 120 ft.) in the short time of 20 working weeks. The contractors are the Mitchell Construction Company, Limited, Peterborough.

The 2 in. diameter steel tube scaffold, designed and erected by the Manchester depot of Mills Scaffold Company, Limited, was tied to the inside face of the reinforced-concrete shell by specially designed fittings. The method was such that it was possible for the scaffolding to be constantly maintained at up to three lifts ahead of the tower erectors, and at the same time it enabled the scaffolding to cater for the maximum concrete production available at all times from the mixer. Moreover, the scaffolding, which was erected by ten men, required only just over half the amount of tubing of a conventional birdcage unit and a saving in cost of between 40 to 50 per cent. over previous methods was effected.

The scaffold was tied to the cooling tower shell by embedded 6 in. by 2 in. steel plates to each of which was tack welded a $\frac{7}{16}$ in. Whitworth nut. Screwed into each nut was a 6 in. bolt, the shank of which was shrouded by a $1\frac{7}{8}$ in. long by $\frac{5}{8}$ in. diameter cardboard sleeve. As the shuttering was 3 ft. 6 in. in depth it was only necessary to insert ties in every other section to provide working lifts of 7 ft. After the mix had been poured and the shutter plates removed, the steel plates were firmly embedded in the concrete, the cardboard sleeves providing suitable clearance holes through the concrete so that the bolts could be removed or replaced as required. The scaffold frame work was then anchored at these points by Mills patent concrete tie clips. These consist of half a standard swivel clip to which is riveted a mild-steel right-angled bracket. One end of the clip is clamped over the scaffold tubing, and the bracket securely pulled up against the concrete face of the tower by means of the bolt. In this way a simple but robust framework could be built up with the minimum of labour and materials. When the scaffolding was stripped down after completion of the tower, all the holes left in the concrete were plugged.

The Human Element

Ships of Ivory

Models are not merely replicas of things bigger; they are creations by people who live for what they make and, in doing, bring to their work the burning enthusiasm of the creator. This year's *Model Engineer* Exhibition, at the New Horticultural Hall, Westminster, open until the end of the month, is distinguished by the presence of Russian exhibitors for the first time.

Four Russian amateur model engineers have brought over nine model ships, including one of the cruiser "Sverdlov" of B & K fame. The modelling of this ship in ivory (out of a solid tusk) and in the most complete detail, is something to remember. Ships are given a very close run by steam locomotives and steam engines. The fascination of these simple, rugged and friendly machines is something few model makers can overcome. The live steam track will attract at least as many as the motor racing track or the water tank on which remote-controlled model ships are demonstrated.

The R.A.F. introduce a modern note with jet aircraft (operated by compressed air) which take off and fly independently. But the future is not portrayed anywhere, at least not in any striking positive manner. It is the past, and to a lesser extent the present, which provides the model makers with their inspiration. They are more concerned with the intricacy of structure, or the sheer beauty of a mechanism. They are artists rather than scientists.

Productivity, Prices and Incomes

The Council of Three have met for the first time to discuss the appointment of staff and the gathering of material for their studies. So far, most of the rumblings off-stage are inauspicious. There is strong criticism of the Government for having appointed a Lord of Appeal to the chairmanship. The *Financial Times* considers that the Government "should not use judges as substitutes to trot on to the field in moments of political difficulty." The trade unions will not have it at any price, since the Council's mere existence implies Government interference with the "sacred right" of collective bargaining.

Both condemnations are a little harsh; the Council is a body of experts, such as the management of a company may bring in to study a difficult problem. This we pointed out in the leader in the issue of August 16. We also underlined the importance of convincing the country that the experts will contribute something worth listening to. So far, Lord Cohen and his two colleagues have acted in a very preliminary way. When they meet next October they will have a great many facts to consider. But this is a long time to wait for action (will there be action then?) from a body which is there to bring about a better understanding of inflation and its consequences.

Strike of Tyrants

Electricians are powerful fellows, for without them industry cannot keep going for long. The truth of this was quickly demonstrated at the Fisher and Ludlow plant in Birmingham where 114 maintenance engineers were on strike: some 1,000 men, non-strikers, were idle in their own factory and several thousand in the car plant of British Motor Corporation (who own Fisher and Ludlow). This number could have swollen rapidly into five figures had the strike gone on.

The dispute began over bonus payments and was "unofficial." The Electrical Trades Union spent a great deal of time and energy in trying to persuade the strikers to return to work. Their failure to do so by last week-end, after 5 days of strike, was some indication of the problems the E.T.U. would have to face if their leadership was less militant. To be opposing a strike is for them a part even more strange than it was to Mr. Cousins at Covent Graden recently.

The power of these few men raises important problems for British industry. The vast degree of electrification which has gone on since the war has made maintenance electricians key personnel in most factories. They have won a position of influence out of all proportion to their numbers. The impact of this strike on other unions has been such that the whole movement is smarting. Inevitably it is within the movement that a solution must be found.

European Education

The existence in Luxembourg of a European school, set up in 1953 for the children of the European Coal and Steel Community staff, has sparked off a movement towards common standards in European education. The six members of the Community—Belgium, France, Western Germany, Italy, Luxembourg and the Netherlands—have recently agreed on the award of a "Baccalauréat Européen," or a European school-leaving certificate.

This is the first time anything of the kind has been attempted. The certificate will be accepted in all six countries as a qualification equivalent in all respects to those given in national schools. The fact that it cuts across frontiers and overcomes the formidable obstacles of academic tradition and prejudice is evidence that the common market movement is growing stronger and has deep social and political significance. This has implications in many fields, particularly in respect of the mobility of labour.

If a common curriculum is adopted in Europe's schools, with due emphasis on the study of languages, it should become relatively simple for a youngster to do his apprenticeship in, say, France, seek his experience in Belgium and Western Germany and settle down in Italy. The seeking of experience across frontiers was a feature of the crafts in the Renaissance. It may again strengthen and enliven Europe's workers.

Sedate Left Wheel

The annual Trades Union Congress at Blackpool next month promises some fireworks. Two unions, the Constructional Engineering Union ("spidermen") and the Public Employees are calling for a declaration by the T.U.C. that they stand by their traditional policy of "public" or "social" ownership. The odds are that Mr. Gaitskell's state shares will have a rough passage, and that the Congress may well end with a policy different from that of the Labour Party. The "abandonment of principle" which trade unionists, including Mr. H. G. Brotherton, president of the Confederation of Shipbuilding and Engineering Workers, have underlined will inevitably arouse sentiment both on the "traditional" side of the Congress and on the "militant" side.

On other vital issues of the day the T.U.C.'s policy is expected to move some way to the left. Mr. Frank Cousins will ask the Congress to reject wage restraint, and strong disapproval of Mr. Macmillan's "impartial body" of "three wise men" will be expressed by the boilermakers and the Civil Service clerks. As was noted last week in these columns, there is a tendency for union leadership to move to the left, closer to the expressed viewpoint of the rank and file. But there is much that is conservative in British trade unionism—the forthcoming Congress may well prove equally critical of the Labour Party and of the Government. The list of resolutions does not make good reading: the evidence is that the British trade union leader is still very far from well advised on the threat to the livelihood of his members of unchecked inflation.

Travolators to the Rescue

Sleepy morning travellers alighting at the Bank (City Railway) station will be able to stand still and be conveyed over the 300 ft. from the platform to the station exit. The same people, tired after their day's work, will find the moving ramp taking them from the exit to the platform.

The plan for the reconstruction of the Bank station provides for the installation of two 4 ft. wide moving belts to be housed in a new tunnel to the north of the present subway. From the platform they will rise 42 ft. in their 300 ft. length to the exit level and carry passengers along this one-in-nine gradient at a maximum speed of 180 ft. per minute. At peak times both will move in the same direction, with a combined capacity of some 10,000 people an hour. This type of installation has become popular in the United States, where it has been found a great help in getting crowds moving quickly and evenly.

The belts are known as "travolators"—previously they have been called just plain conveyors, or moving sidewalks, or other composite names. Travolator belongs to the automatic nucleonic space age. It is yet another tool in the hands of men to control others—this time the rate of flow to and from work.

U.S. Union Calls for Price Cuts

Few trade unions are better at making use of prevailing public sentiment to further their cause than the United Automobile Workers Union. Inflation is the bogy-man, so Mr. Walter Reuther, their president, tilts at inflation. His union, he writes to companies, would considerably soften their next round of wage demands if the car manufacturers undertake to reduce the prices of their 1958 models by 100 dols.

One hundred dollars means a great deal to an American motoring public faced with rising prices in all directions. "Softer" wage demands mean very little to the employers. Yet, shorn of its theatricals, Walter Reuther's suggestion is realistic and progressive. It means that the U.A.W.U. consider that a high demand for cars is the best insurance against lay-offs and that price cuts would go some way towards stimulating demand. It was good sense as well as good public relations.

The president of General Motors, Mr. Harlow Curtice, turned it down flat and he has been followed by Mr. Henry Ford, who described the proposal as an empty one, inferring that it was no more than a "propaganda broadside." The feeling in the industry as a whole is that price levels must rise, not fall. The Union's economics may be right in concluding that high prices build sales resistance among car owners. But they were too vague in respect of their own position. Mr. Curtice's immediate counter-proposal was for extension of the present wage contract for two years beyond the expiry date of end of May next year. He pointed out that this contract already embodies clauses which relate the wage level to the cost of living index and to productivity increases. A mere renewal will add partly to the manufacturers' costs, far too much to enable them to reduce prices. In the United States, as in this country, the danger to unions and employers alike is inflation and Mr. Curtice considers that even "softened" demands would partly add to inflationary pressures.

ENGINEERING

An Illustrated Weekly Journal

Current contracts include:—
British Celanese Ltd.,
Imperial Chemical Industries Ltd.,
Brymbo Steel Works Ltd.,
Stewarts and Lloyds Ltd.,
Steel Company of Wales Ltd.

Makers since 1790 of:—
Railway and other bridges;
Constructional steelwork;
Unit bridging; Iron paving;
Wrought Iron bars;
Overhead cranes;
Railway wagons and Mine cars;
Meehanite castings;
Mining and Sheet Metal machinery;
Sewage ejectors and pumps;
Wool washing machinery;
Aglite lightweight aggregate;
High quality bricks.

BUT 9296

ORE and ADMIRATION

Steelmen, however old, never fail to feel—no matter how many times they've seen it—the awe and excitement of a furnace in full blast. From apprentice to Chief Smelter, that amazingly skilled aristocrat of the foundries, the thrill remains as sharp as ever with the sweat and heat and glory of it all.

It is well known by steelmen that high purity oxygen in blast, Bessemer or open hearth makes for considerably greater heat much more cheaply. This oxygen is best produced by Butterley on-site Tonnage Oxygenerators and allows a still wider range of quality steels.

While being compact and efficient, these plants produce a continuous supply of oxygen and or nitrogen at any desired purity and pressure at any quantity needed where there's work with oxygen afoot.

Sole production and sales rights have been acquired by Butterley from America for U.K., British Commonwealth and certain European countries. If you can use oxygen, consult Butterley Oxygen Division.

If you can use Oxygen, consult

BUTTERLEY

OXYGEN DIVISION

Oxygen Division, The Butterley Company Limited, 9 Upper Belgrave St., London, S.W.1. Tel: SLOane 8172/3

47